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[COMMITTEE PRINT]

READINGS ON SOLID WASTE MANAGEMENT AND RESOURCE RECOVERY

PREPARED FOR THE

SUBCOMMITTEE ON THE ENVIRONMENT AND THE ATMOSPHERE

OF THE

COMMITTEE ON SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

NINETY-FOURTH CONGRESS

SECOND SESSION

BY THE

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Serial Y

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LETTER OF TRANSMITTAL

House of Representatives
Committee on Science and Technology
March 30, 1976

Honorable Olin E. Teague
Chairman, Committee on Science
and Technology
U. S. House of Representatives
Washington, D. C. 20515

Dear Mr. Chairman:

I am transmitting herewith an annotated literature compilation dealing with solid waste and energy and resource recovery from solid waste. This will be used as a background document for our upcoming hearings on legislation on this subject which is now before our Committee.

I commend the Report to you and all Members of the Committee.

Sincerely,

George E. Brown Jr.

George E. Brown, Jr.
Chairman, Subcommittee on the
Environment and the Atmosphere

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Congressional Research Service
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March 30, 1976

LETTER OF SUBMITTAL

The Honorable George E. Brown
U. S. House of Representatives
Washington, D. C.

Dear Congressman Brown:

In response to your request to provide background for hearings, we have prepared the following collection of "Readings on Solid Waste Management and Resource Recovery."

The first two chapters focus on the magnitude of the solid waste problem, and review existing legislation. Programs of the Federal government are outlined in Chapter III, followed by a look at the technical and institutional obstacles to resource recovery in the fourth and fifth sections. The final chapter examines ongoing areas of research, and touches on the problems of hazardous wastes and sewage sludge.

The compiler was Mark E. Anthony Reisch of the Environment and Natural Resources Policy Division.

Sincerely,

Norman Beckman
Acting Director, CRS

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READINGS ON SOLID WASTE MANAGEMENT AND RESOURCE RECOVERY

Prepared by the

Mark E. Anthony Reisch, Analyst
Environment and Natural Resources Policy Division
Congressional Research Service
Library of Congress

At the request of the
Subcommittee on the Environment and the Atmosphere
of the Committee on Science and Technology
U. S. House of Representatives

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SUMMARY

One would be hard put to think of an economic activity so efficient that it generated no residue of any kind. And if one does come up with such an activity -- say, a teacher speaking to his students, or a musician performing for his audience -- it must be narrowly defined, and, in all probability, the support systems of the teacher, the musician, and their congregations must be ignored. The teacher must speak with no notes, the musician perform with instruments having a long life-expectancy. Needless to say, the audience cannot be permitted to litter, not even their ticket stubs. In short, the economic activity must be of short duration and have few people involved.

Societies do not grow this way; civilizations do not rise without waste products. (Even more so are they incapable of declining without creating trash.)

Given the fact of solid wastes, then, society's question must be what to do with them. Primitive communities use next to everything. There is little they produce that cannot be burned for heat or plowed into the ground when it has no more use. If a knife blade is brought in from afar, it will be honed and honed again until only its rust is left to be returned to the earth.

We do not live in such a place.

As citizens of the most technologically advanced nation in history, we import goods and materials from every corner of our world. The United States is so wealthy that our discards are seized by other peoples. Scrap iron and waste paper are shipped from our ports to become the inputs of industries thousands of miles away. We think our land so rich that we export sewage sludge to become fertilizer on other continents.

In recent years this attitude has been changing. Some observers have named Earth Day as the turning point; others cite the oil embargo of the winter of 1973-74. One event brought the issue to the public's consciousness, the other emphasized the need for alternative fuel sources, and permanently changed the economics of energy recovery from solid waste. During the same period pilot plants and demonstration projects were showing that the technology for reclaiming materials and energy from trash existed, even if not quite perfected.

The first three chapters of this collection may be considered as basic background on the issue and on the Federal role. Chapter IV deals mainly with the technology and its problems, and Chapter V with the institutional constraints encountered in an economy oriented to virgin material use. The last chapter is on current research, hazardous wastes, and sewage sludge. For the reader who wishes to be selective in his approach the following summary will provide a guide.

The introductory selections of Chapter I take a statistical look at solid waste and discuss the benefits of resource recovery. The chart that is item 1 simply points out that the quantity of trash grows as economic development rises. The second selection presents data on and interpretation of the quantity and composition of solid wastes. For 1973 total post-consumer municipal wastes amounted to 135 million tons, a per capita rate of 3.5 pounds per day. Overall, only about 7 percent was recycled, and of this amount 93 percent was paper. It is projected that by 1990 municipal wastes will be generated at the rate of 225 million tons annually, and 26 percent (58 million tons) will be recovered. The projections are particularly uncertain due to present conditions of rising material and energy prices and changing international bargaining relationships.

Item 3, the benefits of resource recovery and waste reduction, discusses impacts on local waste management, the conservation of natural resources, and environmental protection. With municipal collection and disposal costs expected to double in the 1974-85 decade, alternative methods will be sought. Resource recovery eases the pressure on landfill sites by reducing the quantity of residue by as much as 95 percent, and it permits the closing of incinerators which, as a group, have a poor air pollutant control record; dangers of leachate from open dumps and landfills contaminating ground and surface waters are likewise reduced. Increasing pressure on the world's natural resource base is already being felt and is anticipated to increase over time. The post-consumer waste stream could provide between 6 and 11 percent of current annual U.S. production of various major metals, up to 20 percent of paper, and between 1 and 2 percent of energy requirements. This also has implications for the international balance of trade, and supply from foreign sources in the face of instances of nationalization and organization of cartels. Lastly, while it is difficult to quantify and analyze, the preservation and improvement of environmental quality represents a third set of problems for which resource recovery and waste reduction can contribute some measure of solution.

Chapter II describes the requirements, primarily research and development, of the Solid Waste Disposal Act and the Resource Recovery Act of 1970. The text of the amended law appears as item 5.

The legislation gave the Environmental Protection Agency and the Bureau of Mines the prime Federal responsibility. Their programs are dealt with in Chapter III. Within EPA, the designated organization is the

Office of Solid Waste Management Programs (OSWMP), which issued its Solid Waste Management Strategy (item 6) in October, 1974. The strategy identifies the major issue as one of improper waste management, resulting in problems ranging from extreme health and environmental damages to resource wastage. The primary reason is that improper disposal is cheap compared to environmentally acceptable practices. OSWMP's program has two goals, the first being environmental protection, with particular emphasis on preparing for a hazardous waste regulatory role. It is anticipated that the States will play a large part, and a principal objective is to strengthen their ability to do so, both administratively and legislatively by establishing authority over the disposal of all wastes. The second goal is resource conservation, with particular attention to energy recovery from mixed urban wastes. Other objectives are to promote materials recovery, to conduct studies on source reduction, and to encourage the consumption of secondary materials through Federal procurement and other actions.

An excerpt from OSWMP's annual report for fiscal year 1975 is item 7. The Hazardous Waste Management Division is establishing a data base, and conducting major studies in 13 industry groupings to define quantitatively and qualitatively their hazardous waste streams. It is also developing the tools and capabilities to regulate hazardous wastes, and is assisting the States to do the same. Major program elements of the Systems Management Division are technical assistance to municipalities, and research into land disposal and special wastes. During FY 1975 an increased effort was made at understanding the effects of disposing sewage sludge on land. The Resource Recovery Division manages five large demonstration pro-

jects, and conducts studies and analyses to determine means of increasing the demand for secondary materials. In addition, it is responsible for developing the guidelines on resource recovery mandated by law.

Next, the director of the Bureau of Mines describes recent activities of his organization, including the development of two processes for materials recovery, one from incinerator residues, the other from raw refuse. The Bureau has also worked on better methods of processing junked autos. His testimony contains several interesting charts on quantities of new minerals required each year, amounts imported and exported, and their costs.

Chapter IV examines the potential for resource recovery and looks at several projects and the problems they have encountered. In the first selection (item 9) EPA estimates that 900 trillion Btu's were available in the municipal refuse of the Standard Metropolitan Statistical Areas in 1973. This is equal to the amount of energy in 154 million barrels of oil; other equivalents are 10 percent of all the coal consumed by utilities in 1973, and 28 percent of the oil projected to be delivered through the Alaskan pipeline. Based on current plains, it is projected that by 1980 almost 30 cities and counties will be operating the equivalent of about thirty-six 1,000 ton/day plants recovering 85 trillion Btu's per year. The agency notes that at present the only technologies that can be considered "commercially available" are the generation of steam in waterwall incinerators fueled solely by unprocessed wastes, and the use of prepared solid waste as a supplement to pulverized coal in electric utility boilers.

Item 10 reviews the markets for recycled materials during a recent period of severe fluctuation and discusses some of the market factors involved. The next piece could be described as a businessman's look at

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the resource recovery industry. Problems encountered by the different companies marketing recovery systems are noted, and the positive side of the slow implementation of resource recovery is pointed out: a rash of cities selling reclaimed materials would glut the market and prices would fall drastically; and, with many of the systems unproven at full-scale, there would be failures that would not only be expensive, but would deter other cities considering resource recovery.

The technology and economics of six resource recovery demonstrations supported by EPA are described in item 12. The six demonstrations are (1) the use of shredded, classified waste as a coal substitute in St. Louis; (2) pyrolysis to produce a gaseous fuel for steam generation in Baltimore; (3) pyrolysis to produce a liquid fuel in San Diego County; (4) the use of processed waste as a fuel oil substitute in Delaware; (5) the wet pulping of waste for materials recovery in Franklin, Ohio; and (6) the recovery of materials from incinerator residue in Lowell, Massachusetts. The Lowell project was cancelled when it was discovered that the incinerator could not meet air pollution standards without very expensive capital improvements.

The St. Louis demonstration, in particular, has received wide attention in the press and has been the model for a number of other cities contemplating similar projects. The Union Electric Co., in whose boilers the waste was fired, subsequently announced plans to build additional processing facilities in order to use the entire waste output of the St. Louis metropolitan area. Problems have been encountered, however, with air pollution, ash removal, and possible health hazards as described in item 13.

The Delaware project has not yet been constructed, but it has already been the subject of controvery. At first rejected by EPA for a demonstration grant, and later approved, the project required a change in scope. The General Accounting Office questioned the usefulness of the demonstration. Their review of the facts and EPA's reply are presented in item 14.

The CPU-400 project is an innovative research and development effort that has encountered a number of technical problems. The waste is burned in a pressurized fluid bed incinerator, and the gases are used to turn a turbine which moves an electrical generator. Particles in the gases, however, eroded the blades of the turbine. The problem was to clean the gas without reducing the pressure to such an extent that it could not turn the turbine. An executive from the contracting Combustion Power Company discussed the difficulties in hearings held in March 1974 (item 15).

The next two articles present the bright and cloudy sides of the Nashville Thermal Transfer Corp. Established as a nonprofit corporation, it was financed by a bond issue and received no Federal assistance. Air pollution and other technical problems have caused financial predicaments both for the company and their private customers.

Items 18 and 19 deal with the recovery of methane gas from sanitary landfills. While this method offers no solution to the waste disposal problem of cities, its comparatively low cost makes it an attractive minor energy source. The methane, along with other gases and water, is produced naturally as the garbage in the landfill decomposes. Wells are drilled, and the gas is captured and purified. Projects in Palos Verdes, California, and Mountain View, California are described.

The last article in this chapter argues against the high technology systems like those reviewed above. If individual households spent 6 minutes a week separating their trash, the author states, a $100,000 plant could do the job of a multi-million dollar facility.

The problems discussed in Chapter IV were primarily technological. Chapter V deals with obstacles in existing law and institutional arrangements, and the availability of capital. Item 21 considers the role that the Federal procurement process can play in creating demand for products containing recycled material. While the U.S. Government is a large consumer of many products, its purchases represent only a small percentage of national output. At least as important as the direct impact, though, is the fact that Federal procurement specifications are widely copied by State and local governments and some industries. Three Federal recycling programs are also reviewed: the General Services Administration's procurement of recycled paper, the army's tire retreading program, and the Joint Committee on Printing's use of secondary fibers in printing and publishing papers.

Item 22 is actually a continuation of the previous excerpt and deals with the tax benefits available to producers of virgin materials. Inasmuch as they do not apply to secondary materials industries they constitute a subsidy for virgin material use. The tax benefits are depletion allowances, the ability to deduct from current income certain development costs (expensing of capital expenditures), capital gains treatment, and several foreign tax allowances. EPA conducted an analysis of virgin materials which compete with material that could be recycled from solid waste. Covered were timber, oil, gas, coal, iron ore, primary aluminum, and glass sand

for the year 1970. The tax benefits to these industries came to over $2 billion, of which $1.8 billion was for petroleum and natural gas. The situation has changed completely since the passage of P.L. 94-12 in 1975, which repealed, with some exceptions, the depletion allowance on oil and gas.

Another institutional factor affected by recent legislation is the topic of discriminatory freight rates. Scrap materials are subject to higher, purportedly discriminatory, rates than virgin ores with which they compete. The Railroad Revitalization and Regulatory Reform Act which was signed into law in February, 1976, should lead to an end to this problem. The new law calls for an investigation of the rate structure and establishes procedures for eliminating any unjust or unreasonable rate differentials between new and recycled materials.

Item 23 discusses several constraints to implementation of energy recovery systems. Technical and market uncertainties present a chicken and egg situation: risks exist because the systems have not operated successfully for long periods of time, but the risks will be reduced only after a number of cities and companies have taken a chance and accumulated operating data. Lack of information and failure to engage in adequate planning by municipalities is another difficulty because of the complicated nature of the endeavor and because so many of the variables are dependent on the local situation. And, there are a variety of State laws, such as those restricting contract length and requiring competitive bidding, that jeopardize resource recovery systems. In the last part of this piece EPA considers the availability of financing, and concludes that, while there may be some difficulties, no major shortage of capital is anticipated.

The next two articles also deal with financing. The authors of number 24 are with a major investment bank and discuss alternative approaches, and risk-sharing options. Item 25 analyzes the recently revised Internal Revenue Service regulations permitting tax-exempt financing of solid waste management resource recovery facilities.

Finally, item 26 is a report from the Wall Street Journal on the bonds issued for the Saugus, Massachusetts plant that will generate and sell steam.

Two views from academia open Chapter VI. Item 27 recounts the areas in which university research in solid waste management is being carried out. Effects of land disposal, and particularly the leachate problem, have engendered a great deal of interest, as have the biological processes involving such things as methane and ethanol production. Two other areas mentioned are sludge disposal and the application of systems analysis to solid waste managemet. The author closes with a plea for support for the training of personnel. Item 28 concentrates on several projects directed at the recovery of consumer wastes. The author reports on cryogenic treatment of automobile tires, the separation of nonferrous scrap by induction. the hydrolysis of refuse to produce ethyl alcohol, and computer-based mechanical sorting of municipal solid waste.

The next piece is an excerpt of an article on anaerobic digestion. Like drilling wells in sanitary landfills, which was dealt with in Chapter IV, the product recovered is methane gas. The difference is that the natural degradation process is speeded up by controlling the temperature and other variables in a mechanical digestor.

Article number 30 surveys several fermentation processes. Briefly described are: protein from bagasse by bacterial fermentation, production of fungal protein from cellulose, photodegradation of cellulose, fungal enzymes to produce glucose from waste cellulose, protein production using fungi fermentation, protein from alcohols, and growing yeast from solid waste.

From research, we switch to hazardous wastes in item 31. Section 212 of the Resource Recovery Act of 1970 required that EPA prepare a comprehensive report to Congress on the storage and disposal of hazardous wastes. The summary and conclusions of that report are presented in item 31, in which EPA recommends a regulatory program for their treatment and disposal. The States would implement the program subject to Federal standards in most cases.

The final selection is an article from Environmental Science & Technology which discusses the problems involved in disposing of sewage sludge and reviews the various methods employed.

I. INTRODUCTION

(Excerpted from: Richard N. Farmer, Farmer's Law: Junk in a World of Affluence. New York: Stein and Day, 1973.)

Figure 1: Country Trash Profiles

Countries or Areas	Per Capita GNP Per Yr.	Observable Trash
South Sea Islands, Primitive, and remote African tribes, Desert nomads	under $50	Everything-nothing gets used.
Afghanistan, Senegal, Sudan, Tanganyika, India, Pakistan, Cambodia, Tunisia, Bolivia, Jordan, Nepal, Upper Volta, Yemen, etc.	$ 51–$ 200	Nothing or very little—everything gets used for some purpose, often in ingenious ways—autos totally stripped.
Argentina, Brazil, Mexico, Lebanon, Morocco, Jamaica, Greece, Malaya, etc.	$201–$ 500	Low-grade material—broken bottles, cement fragments, occasional tires (rare), leaking plastic bottles, and similar autos almost, but not quite totally stripped.
Japan, Venezuela, Israel, Finland, Iceland	$ 501–$1200	Beginnings of affluence: usable trash accumulates. Bottles, cans, tires, occasional abandoned cars, etc.
West Germany, United Kingdom, Switzerland, Norway, Australia, France, etc.	$1201–$2500	Trash problems becomes a public issue: what to do with it? Abandoned cars, throwaway containers, paper as a key problem.

(Excerpted from: U.S. Environmental Protection Agency, Third Report to Congress: Resource Recovery and Waste Reduction. Washington, U.S. Government Printing Office, 1975.)

THE QUANTITY AND COMPOSITION OF POST-CONSUMER SOLID WASTE

The *Second Report to Congress* (March 1974) indicated considerable improvement in our knowledge of both total quantity and composition of the nation's post-consumer solid waste stream. For the first time, estimates were presented detailing the composition of the 1971 waste stream both by material and by product type.[2, p. 3] The work done in the year since that report has not provided reasons to reject or significantly alter the bases for the 1971 estimates.[3,4] They have been updated to 1973 and additional details developed on composition by product type, on recycling, and on projections of future trends.

Estimates for 1973

EPA's current estimates for U.S. post-consumer municipal waste for 1973, based on reported material flow statistics for 1973 and earlier years, are presented in Table 1. This table is organized in the same format as the original table for 1971 appearing in the last *Report to Congress*, with all figures updated to 1973 values. The same definitions and similar methods of calculation are used, so the 1973 data are directly comparable to the 1971 estimates.[2] They are preliminary in the sense that they are based in part on industry statistics for 1973 that are still subject to revision by government and trade association sources. The following were the more significant changes between 1971 and 1973 (Table 2):

Total waste generation:

- Total post-consumer municipal waste increased by 10 million tons (8 percent) from 125 to 135 million tons.
- Per capita generation increased from 3.3 to 3.5 pounds per day (6.3-percent growth).

TABLE 1

MATERIAL FLOW ESTIMATES OF RESIDENTIAL AND COMMERCIAL POST-CONSUMER NET SOLID WASTE DISPOSED OF, BY MATERIAL AND PRODUCT CATEGORIES, 1973*†

Material	Product category (In millions of tons, as generated)‡							Totals			
								As-generated weight‡		As-disposed weight§	
	Newspapers, books, magazines	Containers, packaging	Major household appliances	Furniture, furnishings	Clothing, footwear	Food products	Other products	Million tons	Percent	Million tons	Percent
Paper	11.3	23.3	–	tr.	tr.	–	9.6	44.2	32.8	53.4	39.6
Glass	–	12.1	tr.	tr.	–	–	1.1	13.2	9.9	13.4	10.3
Metals	–	6.5	1.9	0.1	tr.	–	4.0	12.5	9.3	12.7	9.9
Ferrous	–	5.6	1.7	tr.	–	–	3.7	11.0	8.2		
Aluminum	–	0.8	0.1	tr.	–	–	0.1	1.0	0.7		
Other nonferrous	–	0.1	0.1	tr.	–	–	0.2	0.4	0.3		
Plastics	tr.	3.1	0.1	0.1	0.2	–	1.6	5.0	3.7	5.6	4.1
Rubber and leather	–	tr.		tr.	0.5	–	3.0	3.6	2.7	3.7	2.7
Textiles	tr.	tr.	–	0.6	0.6	–	0.7	1.9	1.4	2.1	1.6
Wood	–	1.9	–	2.5	tr.	–	0.5	4.9	3.6	4.9	3.6
Total nonfood product waste	11.3	46.9	2.1	3.4	1.3		20.5	85.4	63.5	96.0	71.1
Food waste	–	–	–	–	–	22.4	–	22.4	16.6	18.0	13.3
Total product waste	11.3	46.9	2.1	3.4	1.3	22.4	20.5	107.8	80.1	114.0	84.4
Yard waste								25.0	18.5	19.0	14.1
Misc. inorganics								1.9	1.4	2.0	1.5
Total								134.8	100.0	134.8	100.0

*Smith, F. A., and F. L. Smith, Office of Solid Waste Management Programs, Resource Recovery Division. Data revised Dec. 1974.

†Net solid waste disposal defined as net residual material after accounting for recycled materials diverted from waste stream.

‡"As-generated" weight basis refers to an assumed normal moisture content of material in its final use prior to discard, for example: paper at an "air-dry" 7 percent moisture; glass and metals at zero percent.

§"As-disposed" basis assumes moisture transfer among materials in collection and storage, but no net addition or loss of moisture for the aggregate of materials. Based on estimates in: Niessen, W. R., and S. H. Chansky. The nature of refuse. *In* Proceedings; 1970 National Incinerator Conference, Cincinnati, May 17-20, 1970. New York, American Society of Mechanical Engineers. p. 7-8.

TABLE 2

POST-CONSUMER NET SOLID WASTE DISPOSED OF, BY MATERIAL AND PRODUCT CATEGORIES, 1971 and 1973*†

(As-generated wet weight, in millions of tons)

Materials and products	1971	1973	Growth, 1971-73	Percent change
Material composition:				
Paper	39.1	44.2	5.1	13.0
Glass	12.0	13.2	1.2	10.0
Metal	11.8	12.5	0.7	5.9
Ferrous	(10.6)	(11.0)	0.4	3.8
Aluminum	(0.8)	(1.0)	0.2	25.0
Other	(0.4)	(0.4)	0.0	6.0
Plastics	4.2	5.0	0.8	19.0
Rubber and leather	3.3	3.6	0.3	9.0
Textiles	1.8	1.9	0.1	5.5
Wood	4.6	4.9	0.3	6.5
Total nonfood product waste	76.9	85.4	8.5	11.1
Food waste	22.0	22.4	0.4	1.8
Total product waste	98.9	107.8	8.9	9.0
Yard waste	24.1	25.0	0.9	3.7
Miscellaneous inorganics	1.8	1.9	0.1	5.6
Total	124.8	134.8	10.0	8.0
Product composition:				
Newspapers, books, magazines	10.3	11.3	1.0	9.7
Containers and packaging	41.7	46.9	5.2	12.5
Major household appliances	2.1	2.1	0.0	0.0
Furniture and furnishings	3.2	3.4	0.2	6.3
Clothing and footwear	1.2	1.3	0.1	8.3
Other products	18.4	20.5	2.1	11.4
Total nonfood product waste	76.9	85.4	8.5	11.1
Food waste	22.0	22.4	0.4	1.8
Total product waste	98.9	107.8	8.9	9.0
Add: Yard and misc. inorganics	25.9	26.9	1.0	3.9
Total	124.8	134.8	10.0	8.0

*Smith, F. A., and F. L. Smith, Office of Solid Waste Management Programs, Resource Recovery Division. Data revised Dec. 1974.

†Net solid waste disposal defined as net residual material after accounting for recycled materials diverted from waste stream.

Kinds of materials:

- Total nonfood product wastes accounted for most of the growth—8.5 million tons, or a 11.1-percent increase.
- Paper and paperboard wastes were up by 5.1 million tons (13 percent).
- Glass up 1.2 million tons (10 percent).
- Metals up 0.7 million tons (5.9 percent).
- Plastics up 0.8 million tons (19 percent).
- No major waste material decreased in tonnage.

Product categories:

- Containers and packaging wastes increased by 5.2 million tons (12.5 percent) and in 1973 constituted 55 percent of all nonfood product waste and 35 percent of total post-consumer waste. (In 1971 the corresponding percentages were 54 percent and 34 percent, respectively.)
- Waste newspapers, books, and magazines were up by 1.0 million tons (9.7 percent).

In interpreting these growth rates, it should be noted that 1971 was not a very strong year for many

products, whereas 1973 was generally a boom year by comparison. Therefore, the growth rates presented in Table 2 should not be used as trends on which to base future projections, either short-term or long-term.

Readers are also cautioned that data in this section relate to nationwide totals, they may prove to be very inaccurate indicators of conditions in any given State or local area.

A much more detailed accounting of product categories has been prepared for this report (Table 3). This yields a considerably clearer picture of how the waste flows originate, which should be particularly useful in analyses of waste reduction and source separation at the national level. In addition, Table 3 estimates the relationships between "gross discards" (total waste generation before recycling or disposal), "material recycled" from post-consumer gross discards, and "net waste disposed of" (final residual waste remaining after material recovery). Table 4 provides similar estimates by material, rather than product, categories.

It should be recognized that the quantities shown here as recycled include only post-consumer residential and commercial wastes recovered from the product sources listed in Table 3. They do not include material recycled from "pre-consumer" industrial processing, fabricating, or converting operations or from certain post-consumer sources such as demolition or junk auto shredding. Thus, the recycling quantities and percentages shown in Tables 3 and 4 will differ from other reported sources and estimates. This is the first time that comprehensive estimates of post-consumer recycling have been developed for all major materials.

Two major conclusions regarding recycling in 1973 can be drawn from Tables 3 and 4. The first is that very little of the post-consumer wastes (excluding automobiles) is currently recycled. Overall, only about 7 percent of total waste or 10 percent of nonfood product waste was diverted from disposal to recycling in 1973. The second conclusion is that most of the recycling (93 percent of total tonnage) is accounted for by paper products—principally old newspapers, office papers, and paperboard packaging. Of the total amount of paper discarded, 16.5 percent was recycled in 1973. For no other material does the recycled percentage amount to as much as 10 percent.

Future Trend Projections

EPA's most recent projections of waste generation rates to 1990 are presented in Table 5. Unlike the simple extrapolations in last year's *Report to Congress*, the new projections are based mainly on a detailed product-by-product analysis.[1] In addition, as with the 1973 estimates, an attempt has been made to project the quantities of waste that will be recycled or otherwise recovered as resources.

The projections are "baseline" figures in the sense that they are based on an assumption of no new intervention by the Federal Government into the solid waste management field via incentives for resource recovery or waste reduction or new regulations on disposal of municipal solid waste. The future projections do assume a continuation of average historical growth rates for national income and gross national product, although not necessarily for individual product categories. Basically, the projections for future years are based on the same type of material flow analysis and historical data sources used to develop EPA's 1971 and 1973 estimates.

Projection of future solid waste generation has never been subject to greater uncertainties than under present conditions of rising material and energy prices and changing international bargaining relationships. It is still too early to judge the extent to which the materials pricing structure has been permanently altered by the recent massive increases in fuel prices, or whether this should significantly affect either the total picture presented in Table 5 or the underlying data components.

The current projection is that total gross discards will increase quite significantly, up to 225 million tons by 1990. Resource recovery—including both recycling and energy conversion—is projected as increasing quite dramatically, but it must be noted that these figures (especially those for 1985 and 1990) represent the least certain numbers in the table since they are based in part on projections of the number of future large-scale waste-processing installations. Thus, these numbers should be taken with great caution, as should the net waste figures derived from them. As a percent of gross discards, the baseline recovery rate is projected to grow from about 7 percent in 1973 to 17 percent in 1985 and 26 percent in 1990.

TABLE 3

POST-CONSUMER RESIDENTIAL AND COMMERCIAL SOLID WASTE GENERATED AND AMOUNTS RECYCLED, BY DETAILED PRODUCT CATEGORY, 1973*

(As-generated wet weight, in thousands of tons)

Product category	Gross discards	Material recycled		Net waste disposed of		
		Quantity	Percent	Quantity	% of total waste	% of nonfood product waste
Durable goods:	14,700	300	2	14,400	11	17
Major appliances	2,200	100	4	2,100	2	2
Furniture, furnishings	3,400	0	0	3,400	3	4
Rubber tires	2,000	200	10	1,800	1	2
Miscellaneous durables	7,100	0	0	7,100	5	8
Nondurable goods, exc. food:	27,930	3,770	13	24,160	18	28
Newspapers	10,400	2,450	24	7,950	6	9
Books, magazines	3,720	330	9	3,390	3	4
Office paper	6,390	990	15	5,400	4	6
Tissue paper, incl. towels	2,320	0	0	2,320	2	3
Paper plates, cups	600	0	0	600	†	1
Other nonpackaging paper	1,300	0	0	1,300	1	2
Clothing, footwear	1,300	0	0	1,300	1	2
Other misc. nondurables	1,900	0	0	1,900	1	2
Containers and packaging:	52,270	5,330	10	46,940	35	55
Glass containers:	12,400	275	2	12,125	9	14
Beer, soft drink	6,100	190	3	5,910	4	7
Wine, liquor	1,970	25	1	1,945	1	2
Food and other	4,330	60	1	4,270	3	5
Steel cans:	5,650	60	1	5,590	4	7
Beer, soft drink	1,550	15	1	1,535	1	2
Food	3,140	35	1	3,105	2	4
Other nonfood	960	10	1	950	1	1
Aluminum:	820	35	4	785	1	1
Beer, soft drink‡	440	30	7	410	†	†
Other cans	50	1	2	45	†	†
Aluminum foil	330	4	1	330	†	†
Paper, paperboard:	28,230	4,960	18	23,270	17	27
Corrugated	15,100	3,290	22	11,810	9	14
Other paperboard	6,925	1,045	15	5,880	4	7
Paper packaging	6,205	625	10	5,580	4	7
Plastics:	3,090	0	0	3,090	2	4
Plastic containers	510	0	0	510	†	1
Other plastic packaging	2,580	0	0	2,580	2	3
Wood packaging	1,900	0	0	1,900	1	2
Other misc. packaging	180	0	0	180	†	†
Total nonfood product waste	94,900	9,400	10	85,500	63	100
Add: Food waste	22,400	0	0	22,400	17	26
Yard waste	25,000	0	0	25,000	19	29
Misc. inorganic wastes	1,900	0	0	1,900	1	2
Total	144,200	9,400	7	134,800	100	158

*Smith, F.A., Office of Solid Waste Management Programs, Resource Recovery Division. Nov. 1974.

†Less than 0.5%.

‡Includes all-aluminum cans and aluminum ends from nonaluminum containers.

TABLE 4

POST-CONSUMER RESIDENTIAL AND COMMERCIAL SOLID WASTE GENERATED AND AMOUNTS RECYCLED, BY TYPE OF MATERIAL, 1973*

(As-generated wet weight, in millions of tons)

Material category	Gross discards	Material recycled†		Net waste disposed of		
		Quantity	Percent	Quantity	% of total waste	% of nonfood product waste
Paper	53.0	8.7	16.5	44.2	32.8	51.8
Glass	13.5	0.3	2.1	13.2	9.9	15.5
Metals	12.7	0.20	1.6	12.5	9.3	14.6
Ferrous	11.2	0.2	1.4	11.0	8.2	12.9
Aluminum	1.0	0.04	4.0	1.0	0.7	1.2
Other nonferrous	0.4	0.0	0.0	0.4	0.3	0.5
Plastics	5.0	0.0	0.0	5.0	3.7	5.9
Rubber	2.8	0.2	7.1	2.6	1.9	3.0
Leather	1.0	0.0	0.0	1.0	0.7	1.2
Textiles	1.9	0.0	0.0	1.9	1.4	2.2
Wood	4.9	0.0	0.0	4.9	3.6	5.7
Total nonfood product waste	94.2	9.4	9.9	85.4	63.4	100.0
Food waste	22.4	0.0	0.0	22.4	16.6	26.2
Yard waste	25.0	0.0	0.0	25.0	18.5	29.3
Misc. inorganic wastes	1.9	0.0	0.0	1.9	1.4	2.2
Total	144.0	9.4	6.5	134.8	100.0	157.8

*Estimates by the Resource Recovery Division, Office of Solid Waste Management Programs.

†Resource recovery in 1973 included only material recycling. Energy recovery accounted for negligible amounts.

TABLE 5

BASELINE ESTIMATES AND PROJECTIONS OF POST-CONSUMER SOLID WASTE GENERATION, RESOURCE RECOVERY, AND DISPOSAL, 1971 TO 1990*

	Estimated		Projected		
	1971	1973	1980	1985	1990
Total gross discards:					
Million tons per year	133	144	175	201	225
Pounds per person per day	3.52	3.75	4.28	4.67	5.00
Less: resources recovered:					
Million tons per year	8	9	19	35	58
Pounds per person per day	0.21	0.23	0.46	0.81	1.29
Equals net waste disposed of:					
Million tons per year	125	135	156	166	167
Pounds per person per day	3.31	3.52	3.81	3.86	3.71

*Office of Solid Waste Management Programs, Resource Recovery Division. Data revised Dec. 1974. Projections for 1980 to 1990 based in part on contract work by Midwest Research Institute.

The amount of net waste is shown as growing at a decreasing rate to 1985, and then essentially leveling off as the increase in recovery equals the increment of gross discards.

Even at this point, however, the nation still would be faced with disposing of an annual aggregate post-consumer waste load about 30 million tons (23 percent) greater than at present. This increase is projected to occur even with resource recovery tonnage quadrupling by 1985 and increasing by more than sixfold by 1990.

THE BENEFITS OF RESOURCE RECOVERY AND WASTE REDUCTION

An increase in resource recovery and waste reduction would have a positive impact on a number of recognized national problems. Among these are problems relating to community solid waste management, the conservation of scarce material and energy resources, international trade and balance of payments, and environmental protection. For the most part, however, potential benefit relationships are still very poorly understood, both in conceptual and quantitative terms. The purpose of this section is to summarize some of the more important facts and issues regarding the potential significance of resource recovery and waste reduction to these areas of national concern.

Community Solid Waste Management

Solid waste management problems at the local level can be grouped into three interrelated categories: (1) increasing costs of collection and disposal; (2) increasing political and social difficulties in locating new land disposal sites; and (3) increasing requirements for controlling pollution from local incinerators and landfill sites. These problems are shared by virtually all of our cities to some degree. They will continue to become more severe over time so long as waste generation continues at its present high and rising level.

Collection and Disposal Costs. It currently costs $21 to collect a ton of solid waste and $5 per ton to process and landfill it. These are national average figures for 1974 reflecting current practices in which a majority of communities do not provide environmentally adequate disposal facilities.* From a national perspective, these average local cost figures imply a total direct cost of about $3.5 billion to collect and dispose of the nation's 135 million tons of post-consumer solid waste in 1973.

It is expected that a majority of communities will experience increasing costs over the next 5 to 10 years. These will be increases in "real" costs–i.e., increases over and above those expected due to general effects of inflation on wage rates and prices of equipment and materials. These increases will have two main causes: pollution controls and increased scarcity of available landfill sites.

Increased requirements for pollution control, imposed by State and regional environmental protection agencies in conjunction with Federal guidelines, will impact directly on both incinerator costs and sanitary landfill costs. Increasing scarcity of available landfill sites, brought on by suburban growth, will also mean increased costs, not only for land itself but also for transporting waste over longer haul distances to outlying sites and for additional processing, such as shredding or baling, that may be required to extend the capacity of landfills.

It is not possible to predict accurately what the combined impacts of these various factors will be on average national costs over the next decade or so. However, it is not unreasonable to expect that the average community will face a 20- to 30-percent increase in its direct real costs of solid waste disposal by 1985, even without adding on the effects of general inflation. This implies a national average cost by 1985 of $8 to $12 per ton for disposal (including transfer stations and processing) and perhaps $30 to $35 per ton for collection and disposal combined. The effects of general inflation on wage rates and other cost factors would, of course, push these estimates to higher levels. Adding on an average 4 percent per year inflation rate, for example, would imply a 1985 collection and disposal cost for the average city of $50 per ton.

Landfill Siting. As many community leaders will attest, obtaining new land disposal sites involves social and political problems that go far beyond the

*Depending on local circumstances and level of services provided, reported collection costs vary between $10 and $30 per ton among different localities. Actual disposal costs may range from under $1 per ton for uncontrolled land dumping up to as high as $15 to $20 per ton for incineration (with air pollution controls) and landfilling of the residue. These are direct costs only and do not include any imputed economic value for the "external" environmentally related social costs of waste disposal.

question of land cost alone. Increasingly, local zoning ordinances and neighborhood political pressure groups are becoming effective instruments for preventing any new landfill site development within certain political jurisdictions. The opposition stems mainly from concern about the effects on the status, esthetic qualities, traffic patterns, etc., of the areas surrounding proposed sites, and the consequent effect on property values. In a very real sense, the extent of local opposition to new landfill sites is a proxy measure of the implicit costs that people who live in the vicinity of such sites typically experience. In short, it is a reflection of expected "external costs" of future land disposal—costs that are never reflected in community budget figures, but which are nonetheless real. A community's inability to establish new landfill sites can result in continued operation of obsolete or inadequate incinerators or overburdening of current landfill facilities. It can also lead to inordinately high dumping fees at private landfills. Such problems are becoming a primary motivating force at the local level for resource recovery and waste reduction programs that can reduce the amount of waste going to landfills.

Pollution Control Requirements. Environmental protection objectives require the control of solid waste incineration and landfill operations for public health, ecological, and esthetic reasons.

As of mid-1972, nearly 200 municipal-scale incinerators operated in the United States, processing waste at a rate of about 17 million tons per year.[5] Incinerators produce a variety of atmospheric emissions, and many are also a significant source of untreated wastewater effluent. Historically, incinerators have had a very poor air pollutant control record. Most are in the Northeast quarter of the nation, with over one-half being in the densely populated eastern seaboard States. Thus, their principal contributions to pollution are in areas where the damages are likely to be the greatest.

Most of the solid waste tonnage goes directly to open dumps and landfills. Although open dumps have long been considered unacceptable from both esthetic and public health standpoints, the greater part of municipal waste is probably still disposed of in this manner. As recently as the summer of 1972, it was determined that more than 14,000 disposal sites classified as dumps still operated in the United States. And although sanitary landfills have usually been considered environmentally acceptable, very few have been designed to control leachate. There is increasing evidence that potential underground leachate problems are more serious than previously thought, with adverse implications for the quality of both ground and surface waters.[6]

There are real questions regarding how rapidly local agencies can progress toward environmentally acceptable incinerators and landfills in the face of rising waste loads and rising costs of implementing the desired controls. To the extent that such progress is made, it will be reflected in steeply higher costs of waste disposal. To the extent that control implementation lags, environmental quality will deteriorate further due to the increasing per capita solid waste generation rates.

Conservation of Natural Resources

By a variety of measures, we are becoming an increasingly "material-intensive" society. Not only have we increased our per capita consumption of goods and services, in many cases we have also increased our rate of material use per unit of product consumed. This is reflected both in the waste flow estimates and in basic production and consumption statistics. For example, U.S. consumption of most classes of raw materials has been growing by 20 to 40 percent per decade in the 20th century, and there is some evidence of an increasing rate of growth during the most recent decades.[1, p. 10] EPA's projections indicate 10- to 60-percent increases in consumption of various raw materials and fuels by 1985 over 1972 levels. Typical projections by independent resource economists forecast at least a doubling in U.S. consumption of most raw materials by the year 2000.[7, 8]

Along with increasing material consumption has come an apparently increasing dependency on foreign mineral resources during the post-World War II era.[9] This undoubtedly has been largely a function of the economics of supply rather than our own "running out of resources" in any absolute sense. An important factor here was the overvaluation of the dollar in international trade during most of the past three decades. However, it also reflects the fact that for some raw materials (such as tin and nickel) the

United States does not possess known commercial-scale deposits, and that for some others (such as iron ore) most of our higher grade and more accessible deposits have already been largely depleted.

In the context of international trade, a new system of floating exchange rates together with new instances of nationalization and cartelization of the world's natural resources has to a significant degree created new ground rules regarding access to foreign raw material and energy sources. At the same time, the structure of competition for foreign resources has drastically changed with the rapid economic growth of the U.S.S.R., Japan, and a number of other nations.

The general conclusion is that the world's natural resource base, including that of the United States, will be subject to increasingly extreme pressures over time, and that the international system of distributing these resources will be less favorable to U.S. consumption than in the past. This implies an altered future price structure, with the United States facing generally higher world market prices for many if not most of its imported raw materials and fuels. Under such circumstances, the natural response will be to turn increasingly inward to domestic sources, where possible, in order to reduce adverse effects on specific product prices and foreign trade balances, and to preserve national political autonomy. Our policy of domestic energy development–Project Independence–is a case in point.

From a domestic economic standpoint, the key issues relate to possibilities of future shortages of important industrial raw materials and fuels with attendant decreases in material welfare. These shortages could occur from a technological inability of the United States and other countries to develop new low-cost raw material supplies in pace with rising world demands. They could also result from trade restrictions associated with international power struggles, or simply from attempts of key supplying nations to maximize their returns from trade.

The extent and timing of future shortages is subject to much conjecture and debate.[10-12] Because there is no adequate way at present to assess the relative quantitative importance of these perceived problems, there is no satisfactory basis for quantifying the present social value of resource conservation in monetary or other terms. Nevertheless, few would deny that conservation values are important even though we may not be able at this time to quantify them.

Last year's *Report to Congress* indicated the approximate contributions that a maximum feasible nationwide resource recovery effort might make toward meeting current demands for materials.[2, p.14] Those EPA estimates suggested that 6 to 11 percent of current annual U.S. production of various major metals and up to 20 percent of current paper production could technically be supplied by recycling materials from the post-consumer solid waste stream (as defined in Table 1). Additional resource conservation and foreign trade benefits would stem from waste reduction measures.

More recent work has focused on quantifying the potential national energy savings associated with material recycling, conversion of organic waste into fuels, and waste reduction approaches.[13] The calculations indicate that energy savings well in excess of 1,000 billion Btu (between 1.5 and 2.0 percent of total U.S. energy requirements) could have been achieved in 1972 through waste reduction and resource recovery measures using currently available technology. This suggests the relative order of magnitude of future national potentials for energy conservation through improved solid waste management.

Although such magnitudes could not be considered, by themselves, to be ultimate solutions to our resource supply problems, they would nevertheless represent substantial contributions in both raw material and energy terms.

Environmental Protection

The preservation and improvement of environmental quality represents a third set of problems for which resource recovery and waste reduction can contribute some measure of solution. Degradation of the environment involves physical, chemical, and biological damages from such causes as: the physical destruction of land surfaces by mining and construction, soil erosion from improper forestry and agricultural practices, the contamination of air and water by industrial effluents, the eutrophication of lakes and ponds, toxic chemicals introduced into biological food chains, and accumulations of industrial and

municipal solid wastes as litter or at dump sites. Environmental degradation adversely affects virtually all of the measures of human welfare—health, economic, and esthetic.

Resource recovery and waste reduction most obviously can affect the direct environmental impacts of waste collection and disposal, as discussed earlier. However, the environmental implications of these nondisposal approaches extend far beyond the local incinerator and dump site, since they are inextricably linked to the industrial structure of the economy. Thus, for example, whenever a waste reduction measure reduces the quantity of a material consumed, the quantities of all direct and indirect raw material and energy inputs—and their associated environmental impacts—are correspondingly reduced to some extent. These direct and indirect industrial impacts include not only the raw materials physically included in the final product (such as the iron, aluminum, tin, and lead in a tinplated can) but also the ancillary process chemicals and the fuels required for heat, power, electricity, and transportation. The reduced demands extend back through the material refining stages to crude material preparation and extraction from the earth. They could in some instances also extend indirectly through the industrial structure to capital equipment requirements and the industries that supply them.

Resource recovery has similar implications, except that some offsetting adverse environmental effects can be expected, both in mixed-waste recovery and subsequent industrial processing of the recovered material (such as secondary smelting). Thus far, research results indicate that the environmental effects of recycling are almost always significantly less—usually only a small fraction—compared with those resulting from virgin production.[14,18] With rare exceptions, this holds for all air and water pollutants (both process and energy-related) as well as solid waste generation and degradation of land surfaces.

At this time it is not possible to predict how environmental benefits of particular actions, in the form of reduced environmental impacts from industry, will be distributed across geographic areas and industry groups. Small increments of waste reduction or recovery may have no observable impact at all, since many effects of industrial processes may be insensitive to small changes in material throughput. One of the real difficulties in evaluating the total environmental significance of waste reduction and resource recovery efforts is the diffusion of individual effects across many different industries and geographic regions. As with material and energy conservation benefits, these environmental benefits are not likely to appear either obvious or of much real significance to those at the local decision-making level. In fact, the national industrial pollution control benefits from any one State or local resource recovery or waste reduction project are likely to be so small as to be virtually undetectable. Nevertheless, the total benefits from a multitude of individual local actions can add up to results of national significance.

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II. THE LEGISLATION

(Excerpted from: U.S. Library of Congress, Congressional Research Service, Environmental Protection Affairs of the Ninety-third Congress. Washington: U.S. Government Printing Office, 1975.)

SOLID WASTE MANAGEMENT AND RESOURCE RECOVERY

Background

EXISTING LEGISLATION

The Solid Waste Disposal Act of 1965 and the Resource Recovery Act, passed 5 years later, initiated the Federal Government's major efforts in the field of solid waste management. Essentially fostering a research and development approach, and containing no regulatory provisions, the two laws are administered by the Office of Solid Waste Management Programs (OSWMP) in the Environmental Protection Agency (EPA) and by the Bureau of Mines. OSWMP was the successor to the Bureau of Solid Waste Management which had been in the Department of Health, Education, and Welfare until EPA was created by Reorganization Plan No. 3 of 1970.

The legislation directed EPA to carry out a number of special study and demonstration projects including methods of recovering materials and energy from solid wastes, reduction of solid waste by requiring changes in product characteristics and packaging practices, and incentives and disincentives to recycling both in the marketplace and in public policies. Second, grants were authorized to State, interstate, municipal, and intermunicipal agencies and organizations for planning purposes. The plans could encompass surveys of disposal practices and problems, the development of regional or local recycling systems, and programs for the removal or processing of abandoned automobiles.

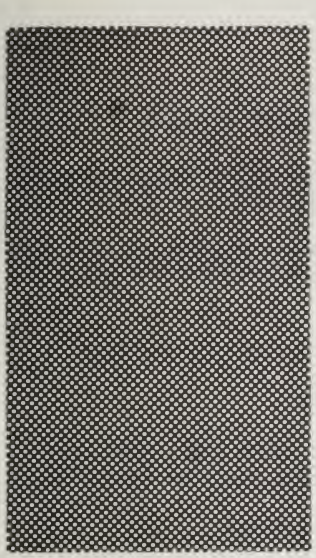
Grants to demonstrate resource recovery systems or to construct new or improved disposal facilities could be made to public agencies. As with the planning grants, cooperative efforts between two or more municipalities entitled them to receive up to 75 percent of the costs; communities acting alone received less. Fourth, EPA was directed to publish guidelines on the collection, separation, recovery, and disposal of solid wastes consistent with public health and welfare and the environment. The guidelines are mandatory on Federal agencies and on anyone receiving a permit to dispose of solid wastes on Federal land. The Agency was also required to recommend model codes, ordinances, and statutes to States and municipalities to implement the guidelines and purposes of the act; and to issue technical and cost information on feasible processes and methods of dealing with solid wastes.

Grants for training personnel (including instructors and supervisory personnel) working in solid wastes or resource recovery were authorized; and EPA was directed to carry out an extensive study on manpower availability and requirements.

One final investigation required of EPA called for planning a national system for the storage and disposal of hazardous wastes, including radioactive, toxic chemical, and biological wastes. These materials were to be identified, current methods of disposal cataloged, and recommendations made concerning their reduction, neutralization, recovery, and disposal. An inventory of possible disposal sites was called for, and long- and short-term costs of developing and maintaining them were to be estimated.

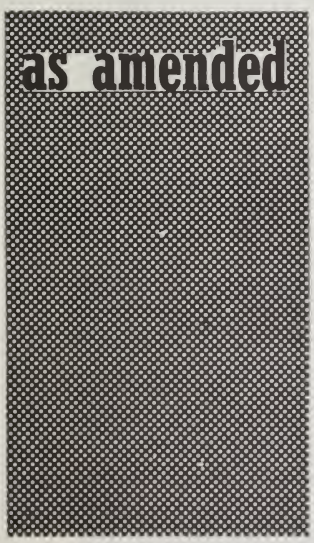
Title II of the Resource Recovery Act created a seven-member National Commission on Materials Policy to make a 2-year study of present resources and technology, anticipated requirements of the United States and the world, and to make recommendations on the supply, use, recovery, and disposal of materials. Economic and demographic factors were to be considered along with the natural resources, energy, and environmental components. "Materials" was defined as all "natural resources intended to be utilized by industry for the production of goods", with the exception of food. The Commission's final report and recommendations for a national materials policy appeared in 1973 and the group was subsequently disbanded.

The responsibility for implementation of the laws was vested in the Office of Solid Waste Management Programs and the Bureau of Mines. The Bureau's programs have been directed to four areas: extraction of metals, minerals, and energy from municipal refuse; improving the methods of recovery of automotive and related scrap; utilization and stabilization of mine, mill, and smelter wastes; and the recovery of materials and energy from industrial wastes.



The Solid Waste Disposal Act

Title II of Public Law 89-272
89th Congress, S.306-October 20, 1965



by The Resource Recovery Act of 1970
Public Law 91-512-91st Congress,
H. R. 11833-October 26, 1970

by Public Law 93-14-93rd Congress,
H. R. 5446-April 9, 1973
(To extend the amended Solid Waste Disposal Act—for one year)

and by Public Law 93-611-93rd Congress,
H. R. 16045-January 2, 1975
(To amend the Solid Waste Disposal Act to authorize appropriations for fiscal year 1975)

4th revision
1975

SW-1.3
U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Solid Waste Management Programs
1975

SOLID WASTE DISPOSAL ACT

[PUBLIC LAW 89–272—89TH CONGRESS, S. 306, APPROVED OCTOBER 20, 1965]

AN ACT To authorize a research and development program with respect to solid-waste disposal, and for other purposes.

* * * * *

TITLE II—SOLID WASTE DISPOSAL[1]

SHORT TITLE

SEC. 201. This title (hereinafter referred to as "this Act") may be cited as the "Solid Waste Disposal Act". **Solid Waste Disposal Act**

FINDINGS AND PURPOSES

SEC. 202. (a) The Congress finds—

(1) that the continuing technological progress and improvement in methods of manufacture, packaging, and marketing of consumer products has resulted in an ever-mounting increase, and in a change in the characteristics, of the mass of material discarded by the purchaser of such products;

(2) that the economic and population growth of our Nation, and the improvements in the standard of living enjoyed by our population, have required increased industrial production to meet our needs, and have made necessary the demolition of old buildings, the construction of new buildings, and the provision of highways and other avenues of transportation, which, together with related industrial, commercial, and agricultural operations, have resulted in a rising tide of scrap, discarded, and waste materials;

(3) that the continuing concentration of our population in expanding metropolitan and other urban areas has presented these communities with serious financial, management, intergovernmental, and technical problems in the disposal of solid wastes resulting from the industrial, commercial, domestic, and other activities carried on in such areas;

(4) that inefficient and improper methods of disposal of solid wastes result in scenic blights, create serious hazards to the public health, including pollution of air and water resources, accident hazards, and increase in rodent and insect vectors of disease,

[1] Title I of P.L. 89–272 amended the Clean Air Act (P.L. 88–206).

have an adverse effect on land values, create public nuisances, otherwise interfere with community life and development;

(5) that the failure or inability to salvage and reuse such materials economically results in the unnecessary waste and depletion of our natural resources; and

(6) that while the collection and disposal of solid wastes should continue to be primarily the function of State, regional, and local agencies, the problems of waste disposal as set forth above have become a matter national in scope and in concern and necessitate Federal action through financial and technical assistance and leadership in the development, demonstration, and application of new and improved methods and processes to reduce the amount of waste and unsalvageable materials and to provide for proper and economical solid-waste disposal practices.

(b)[2] The purposes of this Act therefore are—

(1) to promote the demonstration, construction, and application of solid waste management and resource recovery systems which preserve and enhance the quality or air, water, and land resources;

(2) to provide technical and financial assistance to States and local governments and interstate agencies in the planning and development of resource recovery and solid waste disposal programs;

(3) to promote a national research and development program for improved management techniques, more effective organizational arrangements, and new and improved methods of collection, separation, recovery, and recycling of solid wastes, and the environmentally safe disposal of nonrecoverable residues;

(4) to provide for the promulgation of guidelines for solid waste collection, transport, separation, recovery, and disposal systems; and

(5) to provide for training grants in occupations involving the design, operation, and maintenance of solid waste disposal systems.

DEFINITIONS

SEC. 203.[3] When used in this Act:

(1) [3a] The term "Secretary" means the Secretary of Health, Education, and Welfare; except that such term

[2] Sec. 202(b) amended by sec. 101, P.L. 91–512.

[3] Sec. 203 amended by sec. 102, P.L. 91–512.

[3a] By reason of the establishment of the U.S. Environmental Protection Agency, in December 1970, the references in the cited legislation to "The Secretary" or to "The Secretary of Health, Education and Welfare" should be *changed* to read "The Administrator" or "The Administrator, Environmental Protection Agency." Authority for this change: The President's Reorganization Plan No. 3 of 1970. There are 30 or more places in the legislation where such changes should be made, beginning with Section 203 (p. 2), entitled "Definitions."

Specific references in the legislation to the Secretary of any other Department of the Executive Branch should *not* be changed.

means the Secretary of the Interior with respect to problems of solid waste resulting from the extraction, processing, or utilization of minerals or fossil fuels where the generation, production, or reuse of such waste is or may be controlled within the extraction, processing, or utilization facility or facilities and where such control is a feature of the technology or economy of the operation of such facility or facilities.

(2) The term "State" means a State, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, and American Samoa.

(3) The term "interstate agency" means an agency of two or more municipalities in different States, or an agency established by two or more States, with authority to provide for the disposal of solid wastes and serving two or more municipalities located in different States.

(4) The term "solid waste" means garbage, refuse, and other discarded solid materials, including solid-waste materials resulting from industrial, commercial, and agricultural operations, and from community activities, but does not include solids or dissolved material in domestic sewage or other significant pollutants in water resources, such as silt, dissolved or suspended solids in industrial waste water effluents, dissolved materials in irrigation return flows or other common water pollutants.

(5) The term "solid-waste disposal" means the collection, storage, treatment, utilization, processing, or final disposal of solid waste.

(6) The term "construction," with respect to any project of construction under this act, means (A) the erection or building of new structures and acquisition of lands or interests therein, or the acquisition, replacement, expansion, remodeling, alteration, modernization, or extension of existing structures, and (B) the acquisition and installation of initial equipment of, or required in connection with, new or newly acquired structures or the expanded, remodeled, altered, modernized or extended part of existing structures (including trucks and other motor vehicles, and tractors, cranes, and other machinery) necessary for the proper utilization and operation of the facility after completion of the project; and includes preliminary planning to determine the economic and engineering feasibility and the public health and safety aspects of the project, the engineering, architectural, legal, fiscal, and economic investigations and studies, and any surveys, designs, plans, working drawings, specifications, and other action necessary for the carrying out of the project, and (C) the inspection and supervision of the process of carrying out the project to completion.

(7) the term "municipality" means a city, town, borough, county, parish, district, or other public body created by or pursuant to State law with responsibility for

the planning or administration of solid waste disposal, or an Indian tribe.

(8) The term "intermunicipal agency" means an agency established by two or more municipalities with responsibility for planning or administration of solid waste disposal.

(9) The term "recovered resources" means materials or energy recovered from solid wastes.

(10) The term "resource recovery system" means a solid waste management system which provides for collection, separation, recycling, and recovery of solid wastes, including disposal of nonrecoverable waste residues.

RESEARCH, DEMONSTRATIONS, TRAINING, AND OTHER ACTIVITIES

Research, authority of Secretary, 42 USC 3253

SEC. 204.[4] (a) The Secretary shall conduct, and encourage, cooperate with, and render financial and other assistance to appropriate public (whether Federal, State, interstate, or local) authorities, agencies, and institutions, private agencies and institutions, and individuals in the conduct of, and promote the coordination of, research, investigations, experiments, training, demonstrations, surveys, and studies relating to—

(1) any adverse health and welfare effects of the release into the environment of material present in solid waste, and methods to eliminate such effects;

(2) the operation and financing of solid waste disposal programs;

(3) the reduction of the amount of such waste and unsalvageable waste materials;

(4) the development and application of new and improved methods of collecting and disposing of solid waste and processing and recovering materials and energy from solid wastes; and

(5) the identification of solid waste components and potential materials and energy recoverable from such waste components.

(b) In carrying out the provisions of the preceding subsection, the Secretary is authorized to—

(1) collect and make available, through publications and other appropriate means, the results of, and other information pertaining to, such research and other activities, including appropriate recommendations in connection therewith;

(2) cooperate with public and private agencies, institutions, and organizations, and with any industries involved, in the preparation and the conduct of such research and other activities; and

(3) make grants-in-aid to public or private agen-

[4] Sec. 204(a) amended by Sec. 103, P.L. 91-512.

cies and institutions and to individuals for research, training projects, surveys, and demonstrations (including construction of facilities), and provide for the conduct of research, training, surveys, and demonstrations by contract with public or private agencies and institutions and with individuals; and such contracts for research or demonstrations or both (including contracts for construction) may be made in accordance with and subject to the limitations provided with respect to research contracts of the military departments in title 10, United States Code, section 2353, except that the determination, approval, and certification required thereby shall be made by the Secretary. 70A Stat. 134

(c) Any grant, agreement, or contract made or entered into under this section shall contain provisions effective to insure that all information, uses, processes, patents and other developments resulting from any activity undertaken pursuant to such grant, agreement, or contract will be made readily available on fair and equitable terms to industries utilizing methods of solid-waste disposal and industries engaging in furnishing devices, facilities, equipment, and supplies to be used in connection with solid-waste disposal. In carrying out the provisions of this section, the Secretary and each department, agency, and officer of the Federal Government having functions or duties under this Act shall make use of and adhere to the Statement of Government Patent Policy which was promulgated by the President in his memorandum of October 10, 1963. (3 CFR, 1963 Supp., p. 238.)

SPECIAL STUDY AND DEMONSTRATION PROJECTS ON RECOVERY OF USEFUL ENERGY AND MATERIALS

SEC. 205. [6] (a) The Secretary shall carry out an investigation and study to determine—

(1) means of recovering materials and energy from solid waste, recommended uses of such materials and energy for national or international welfare, including identification of potential markets for such recovered resources, and the impact of distribution of such resources on existing markets;

(2) changes in current product characteristics and production and packaging practices which would reduce the amount of solid waste;

(3) methods of collection, separation, and containerization which will encourage efficient utilization of facilities and contribute to more effective programs of reduction, reuse, or disposal of wastes;

(4) the use of Federal procurement to develop market demand for recovered resources;

[6] Sec. 205 added by sec. 104(a) of P.L. 91-512.

(5) recommended incentives (including Federal grants, loans, and other assistance) and disincentives to accelerate the reclamation or recycling of materials from solid wastes, with special emphasis on motor vehicle hulks;

(6) the effect of existing public policies, including subsidies and economic incentives and disincentives, percentage depletion allowances, capital gains treatment and other tax incentives and disincentives, upon the recycling and reuse of materials, and the likely effect of the modification or elimination of such incentives and disincentives upon the reuse, recycling and conservation of such materials; and

(7) the necessity and method of imposing disposal or other charges on packaging, containers, vehicles, and other manufactured goods, which charges would reflect the cost of final disposal, the value of recoverable components of the item, and any social costs associated with nonrecycling or uncontrolled disposal of such items.

Report to President and Congress

The Secretary shall from time to time, but not less frequently than annually, report the results of such investigation and study to the President and the Congress.

Demonstration projects

(b) The Secretary is also authorized to carry out demonstration projects to test and demonstrate methods and techniques developed pursuant to subsection (a).

(c) Section 204 (b) and (c) shall be applicable to investigations, studies, and projects carried out under this section.

INTERSTATE AND INTERLOCAL COOPERATION

SEC. 206.[6] The Secretary shall encourage cooperative activities by the States and local governments in connection with solid-waste disposal programs; encourage where practicable, interstate, interlocal, and regional planning for, and the conduct of, interstate, interlocal, and regional solid-waste disposal programs; and encourage the enactment of improved and, so far as practicable, uniform State and local laws governing solid-waste disposal.

GRANTS FOR STATE, INTERSTATE, AND LOCAL PLANNING

SEC. 207.[7] (a) The Secretary may from time to time, upon such terms and conditions consistent with this section as he finds appropriate to carry out the purposes of this Act, make grants to State, interstate, municipal, and intermunicipal agencies, and organizations composed of

[6] Previous sec. 205 redesignated as sec. 206 by sec. 104(a) of P.L. 91-512.
[7] Sec. 207 added by sec. 104(b) of P.L. 91-512.

public officials which are eligible for assistance under section 701(g) of the Housing Act of 1954, of not to exceed 66⅔ per centum of the cost in the case of an application with respect to an area including only one municipality, and not to exceed 75 per centum of the cost in any other case, of— 82 Stat. 530 40 USC 461 Cost limitation

(1) making surveys of solid waste disposal practices and problems within the jurisdictional areas of such agencies and

(2) developing and revising solid waste disposal plans as part of regional environmental protection systems for such areas, providing for recycling or recovery of materials from wastes whenever possible and including planning for the reuse of solid waste disposal areas and studies of the effect and relationship of solid waste disposal practices on areas adjacent to waste disposal sites, 84 Stat. 1230 84 Stat. 1230

(3) developing proposals for projects to be carried out pursuant to section 208 of this Act, or

(4) planning programs for the removal and processing of abandoned motor vehicle hulks.

(b) Grants pursuant to this section may be made upon application therefor which—

(1) designates or establishes a single agency (which may be an interdepartmental agency) as the sole agency for carrying out the purposes of this section for the area involved;

(2) indicates the manner in which provision will be made to assure full consideration of all aspects of planning essential to areawide planning for proper and effective solid waste disposal consistent with the protection of the public health and welfare, including such factors as population growth, urban and metropolitan development, land use planning, water pollution control, air pollution control, and the feasibility of regional disposal and resource recovery programs;

(3) sets forth plans for expenditure of such grant, which plans provide reasonable assurance of carrying out the purposes of this section;

(4) provides for submission of such reports of the activities of the agency in carrying out the purposes of this section, in such form and containing such information, as the Secretary may from time to time find necessary for carrying out the purposes of this section and for keeping such records and affording such access thereto as he may find necessary; and

(5) provides for such fiscal-control and fund-accounting procedures as may be necessary to assure proper disbursement of and accounting for funds paid to the agency under this section.

(c) The Secretary shall make a grant under this section only if he finds that there is satisfactory assurance that the planning of solid waste disposal will be coordinated, so far as practicable, with and not duplicate other related State, interstate, regional, and local planning activities, including those financed in part with funds pursuant to section 701 of the Housing Act of 1954.

GRANTS FOR RESOURCE RECOVERY SYSTEMS AND IMPROVED SOLID WASTE DISPOSAL FACILITIES

SEC. 208.[8] (a) The Secretary is authorized to make grants pursuant to this section to any State, municipal, or interstate or intermunicipal agency for the demonstration of resource recovery systems or for the construction of new or improved solid waste disposal facilities.

(b) (1) Any grant under this section for the demonstration of a resource recovery system may be made only if it (A) is consistent with any plans which meet the requirements of section 207(b)(2) of this Act; (B) is consistent with the guidelines recommended pursuant to section 209 of this Act; (C) is designed to provide area-wide resource recovery systems consistent with the purposes of this Act, as determined by the Secretary, pursuant to regulations promulgated under subsection (d) of this section; and (D) provides an equitable system for distributing the costs associated with construction, operation, and maintenance of any resource recovery system among the users of such system.

Federal share, limitation

(2) The Federal share for any project to which paragraph (1) applies shall not be more than 75 percent.

(c) (1) A grant under this section for the construction of a new or improved solid waste disposal facility may be made only if—

(A) a State or interstate plan for solid waste disposal has been adopted which applies to the area involved, and the facility to be constructed (i) is consistent with such plan, (ii) is included in a comprehensive plan for the area involved which is satisfactory to the Secretary for the purposes of this Act, and (iii) is consistent with the guidelines recommended under section 209, and

(B) the project advances the state of the art by applying new and improved techniques in reducing the environmental impact of solid waste disposal, in achieving recovery of energy or resources, or in recycling useful materials.

(2) The Federal share for any project to which paragraph (1) applies shall be not more than 50 percent in

[8] Sec. 208 added by sec. 104(b) P.L. 91-512.

the case of a project serving an area which includes only one municipality, and not more than 75 percent in any other case.

(d) (1) The Secretary, within ninety days after the date of enactment of the Resource Recovery Act of 1970, shall promulgate regulations establishing a procedure for awarding grants under this section which— Regulations

(A) provides that projects will be carried out in communities of varying sizes, under such conditions as will assist in solving the community waste problems of urban-industrial centers, metropolitan regions, and rural areas, under representative geographic and environmental conditions; and

(B) provides deadlines for submission of, and action on, grant requests.

(2) In taking action on applications for grants under this section, consideration shall be given by the Secretary (A) to the public benefits to be derived by the construction and the propriety of Federal aid in making such grant; (B) to the extent applicable, to the economic and commercial viability of the project (including contractual arrangements with the private sector to market any resources recovered); (C) to the potential of such project for general application to community solid waste disposal problems; and (D) to the use by the applicant of comprehensive regional or metropolitan area planning.

(e) A grant under this section—

(1) may be made only in the amount of the Federal share of (A) the estimated total design and construction costs, plus (B) in the case of a grant to which subsection (b) (1) applies, the first-year operation and maintenance costs;

(2) may not be provided for land acquisition or (except as otherwise provided in paragraph (1) (B)) for operating or maintenance costs;

(3) may not be made until the applicant has made provision satisfactory to the Secretary for proper and efficient operation and maintenance of the project (subject to paragraph (1) (B)); and

(4) may be made subject to such conditions and requirements, in addition to those provided in this section, as the Secretary may require to properly carry out his functions pursuant to this Act.

For purposes of paragraph (1), the non-Federal share may be in any form, including, but not limited to, lands or interests therein needed for the project or personal property or services, the value of which shall be determined by the Secretary.

(f) (1) Not more than 15 percent of the total of funds authorized to be appropriated under section 216(a)(3) for any fiscal year to carry out this section shall be granted under this section for projects in any one State. Limitation

Regulation

(2) The Secretary shall prescribe by regulation the manner in which this subsection shall apply to a grant under this section for a project in an area which includes all or part of more than one State.

RECOMMENDED GUIDELINES

SEC. 209.[9] (a) The Secretary shall, in cooperation with appropriate State, Federal, interstate, regional, and local agencies, allowing for public comment by other interested parties, as soon as practicable after the enactment of the Resource Recovery Act of 1970, recommend to appropriate agencies and publish in the Federal Register guidelines for solid waste recovery, collection, separation, and disposal systems (including systems for private use), which shall be consistent with public health and welfare, and air and water quality standards and adaptable to appropriate land-use plans. Such guidelines shall apply to such systems whether on land or water and shall be revised from time to time.

Publication in Federal Register

(b)(1) The Secretary shall, as soon as practicable, recommend model codes, ordinances, and statutes which are designed to implement this section and the purposes of this Act.

(2) The Secretary shall issue to appropriate Federal, interstate, regional, and local agencies information on technically feasible solid waste collection, separation, disposal, recycling, and recovery methods, including data on the cost of construction, operation, and maintenance of such methods.

GRANTS OR CONTRACTS FOR TRAINING PROJECTS

SEC. 210.[10] (a) The Secretary is authorized to make grants to, and contracts with, any eligible organization. For purposes of this section the term "eligible organization" means a State or interstate agency, a municipality, educational institution, and any other organization which is capable of effectively carrying out a project which may be funded by grant under subsection (b) of this section.

"Eligible organizations."

(b)(1) Subject to the provisions of paragraph (2), grants or contracts may be made to pay all or a part of the costs, as may be determined by the Secretary, of any project operated or to be operated by an eligible organization, which is designed—

(A) to develop, expand, or carry out a program (which may combine training, education, and employment) for training persons for occupations involving the management, supervision, design, op-

[9] Sec. 209 added by sec. 104(b) P.L. 91–512.
[10] Sec. 210 added by sec. 104(b) P.L. 91–512.

eration, or maintenance of solid waste disposal and resources recovery equipment and facilities; or

(B) to train instructors and supervisory personnel to train or supervise persons in occupations involving the design, operation, and maintenance of solid waste disposal and resource recovery equipment and facilities.

(2) A grant or contract authorized by paragraph (1) of this subsection may be made only upon application to the Secretary at such time or times and containing such information as he may prescribe, except that no such application shall be approved unless it provides for the same procedures and reports (and access to such reports and to other records) as is required by section 207(b) (4) and (5) with respect to applications made under such section.

Study

(c) The Secretary shall make a complete investigation and study to determine—

(1) the need for additional trained State and local personnel to carry out plans assisted under this Act and other solid waste and resource recovery programs;

(2) means of using existing training programs to train such personnel; and

(3) the extent and nature of obstacles to employment and occupational advancement in the solid waste disposal and resource recovery field which may limit either available manpower or the advancement of personnel in such field.

Report to President and Congress

He shall report the results of such investigation and study, including his recommendations to the President and the Congress not later than one year after enactment of this Act.

APPLICABILITY OF SOLID WASTE DISPOSAL GUIDELINES TO EXECUTIVE AGENCIES

SEC. 211.[11] (a)(1) If—

(A) an Executive agency (as defined in section 105 of title 5, United States Code) has jurisdiction over any real property or facility the operation or administration of which involves such agency in solid waste disposal activities, or

(B) such an agency enters into a contract with any person for the operation by such person of any Federal property or facility, and the performance of such contract involves such person in solid waste disposal activities,

Compliance.

then such agency shall insure compliance with the guidelines recommended under section 209 and the purposes

[11] Sec. 211 added by sec. 104(b) P.L. 91-512.

of this Act in the operation or administration of such property or facility, or the performance of such contract, as the case may be.

(2) Each Executive agency which conducts any activity—

(A) which generates solid waste, and

(B) which, if conducted by a person other than such agency, would require a permit or license from such agency in order to dispose of such solid waste,

shall insure compliance with such guidelines and the purposes of this Act in conducting such activity.

(3) Each Executive agency which permits the use of Federal property for purposes of disposal of solid waste shall insure compliance with such guidelines and the purposes of this Act in the disposal of such waste.

(4) The President shall prescribe regulations to carry out this subsection.

Presidential regulations.

(b) Each Executive agency which issues any license or permit for disposal of solid waste shall, prior to the issuance of such license or permit, consult with the Secretary to insure compliance with guidelines recommended under section 209 and the purposes of this Act.

NATIONAL DISPOSAL SITES STUDY

Report to Congress.

SEC. 212.[12] The Secretary shall submit to the Congress no later than two years after the date of enactment of the Resource Recovery Act of 1970, a comprehensive report and plan for the creation of a system of national disposal sites for the storage and disposal of hazardous wastes, including radioactive, toxic chemical, biological, and other wastes which may endanger public health or welfare. Such report shall include: (1) a list of materials which should be subject to disposal in any such site; (2) current methods of disposal of such materials; (3) recommended methods of reduction, neutralization, recovery, or disposal of such materials; (4) an inventory of possible sites including existing land or water disposal sites operated or licensed by Federal agencies; (5) an estimate of the cost of developing and maintaining sites including consideration of means for distributing the short- and long-term costs of operating such sites among the users thereof; and (6) such other information as may be appropriate.

LABOR STANDARDS

40 U.S.C. 461

SEC. 213.[13] No grant for a project of construction under this Act shall be made unless the Secretary finds that the application contains or is supported by reason-

[12] Sec. 212 added by sec. 104(b) of P.L. 91-512.
[13] Former secs. 207 through 210 redesignated as secs. 213 through 216 by sec. 104(b) of P.L. 91-512.

able assurance that all laborers and mechanics employed by contractors or subcontractors on projects of the type covered by the Davis-Bacon Act, as amended (40 U.S.C. 276a—276a–5), will be paid wages at rates not less than those prevailing on similar work in the locality as determined by the Secretary of Labor in accordance with that Act; and the Secretary of Labor shall have with respect to the labor standards specified in this section the authority and functions set forth in Reorganization Plan Numbered 14 of 1950 (15 F.R. 3176; 5 U.S.C. 133z–15) and section 2 of the Act of June 13, 1934, as amended (40 U.S.C. 276c).

49 Stat. 1101; 78 Stat. 238

63 Stat. 108
64 Stat. 1267

OTHER AUTHORITY NOT AFFECTED

SEC. 214. This Act shall not be construed as superseding or limiting the authorities and responsibilities, under any other provisions of law, of the Secretary of Health, Education, and Welfare, the Secretary of the Interior, or any other Federal officer, department, or agency.

GENERAL PROVISIONS

SEC. 215.[14] (a) Payments of grants under this Act may be made (after necessary adjustment on account of previously made underpayments or overpayments) in advance or by way of reimbursement, and in such installments and on such conditions as the Secretary may determine.

(b) No grant may be made under this Act to any private profitmaking organization.

Grants, prohibition.

SEC. 216.[15] (a)(1) There are authorized to be appropriated to the Secretary of Health, Education, and Welfare for carrying out the provisions of this Act (including, but not limited to, section 208), not to exceed $41,500,000 for the fiscal year ending June 30, 1971.

Appropriation.

(2) There are authorized to be appropriated to the Administrator of the Environmental Protection Agency to carry out the provisions of this Act, other than section 208, not to exceed $72,000,000 for the fiscal year ending June 30, 1972, and not to exceed $76,000,000 for the fiscal year ending June 30, 1973, not to exceed $76,000,000 for the fiscal year ending June 30, 1974, and not to exceed $76,000,000 for the fiscal year ending June 30, 1975.[16]

(3) There are authorized to be appropriated to the Administrator of the Environmental Protection Agency to carry out section 208 of this Act not to exceed $80,000,000 for the fiscal year ending June 30, 1972, and

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[14] Sec. 215 as redesignated by sec. 104(b) of P.L. 91–512 further amended by sec. 104(c) of that Act.

[15] Sec. 216 as redesignated by sec. 104(b) of P.L. 91–512 further amended by sec. 105 of that Act.

[16] P.L. 93–14 extended authorization of funding to June 30, 1974; P.L. 93–611 extended authorization to June 30, 1975.

not to exceed $140,000,000 for the fiscal year ending June 30, 1973, and not to exceed $140,000,000 for the fiscal year ending June 30, 1974.[17]

(b) There are authorized to be appropriated to the Secretary of the Interior to carry out this Act not to exceed $8,750,000 for the fiscal year ending June 30, 1971, not to exceed $20,000,000 for the fiscal year ending June 30, 1972, not to exceed $22,500,000 for the fiscal year ending June 30, 1973, and not to exceed $22,500,000 for the fiscal year ending June 30, 1974.[17] Prior to expending any funds authorized to be appropriated by this subsection, the Secretary of the Interior shall consult with the Secretary of Health, Education, and Welfare to assure that the expenditure of such funds will be consistent with the purposes of this Act.

Program Evaluation.

(c) Such portion as the Secretary may determine, but not more than 1 per centum, of any appropriation for grants, contracts, or other payments under any provision of this Act for any fiscal year beginning after June 30, 1970, shall be available for evaluation (directly, or by grants or contracts) of any program authorized by this Act.

Funds, availability.

(d) Sums appropriated under this section shall remain available until expended.

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[17] P.L. 93-14 extended authorization of funding to June 30, 1974.

III. THE FEDERAL EFFORT

Solid Waste Management Strategy

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Solid Waste Management Programs
October 31, 1974

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SOLID WASTE MANAGEMENT STRATEGY

I. Purpose and Summary

The purpose of this document is to present an EPA solid waste program strategy for FY 1975. This document lays the ground work for guidance to EPA headquarters, EPA Regions, and to the States. It is meant to ensure that activities undertaken will conform to this strategy and are consistent with each other. As a statement of EPA's intentions, this paper is also meant to serve as a means of promoting public awareness, encouraging public participation and guiding the public on EPA solid waste management policies. The strategy should be viewed as a dynamic document, intended to be responsive to situations that develop. It will undergo revision to accommodate new needs, problems, and legislative thrusts, but the basic philosophy and framework will be continued.

This strategy is designed to encompass the activities of all agency elements involved in solid waste related activities, and most activities described will involve or require the participation of several offices within EPA. The strategy is designed to serve as a general guide for all types of wastes and residuals disposed of on land, but it is recognized that lead activity related to some residuals falls under the aegis of water or air programs or their respective research counterparts and that these wastes are covered by other agency strategies in more detail.

In summary, the major issue being addressed is one of improper waste management, resulting in problems ranging from extreme health and environmental damages to resource wastage.

The problem is caused by the fact that improper disposal is cheap compared to environmentally acceptable practices. Problems tend to result from improper actions over long periods of time, and result from practices not easily understood or visualized. Aesthetic damages are easily visualized, and represent varying impacts on human health or animal life. On the other hand, for example, groundwater contamination which is not visible can result without a proper understanding and application of the necessary environmental control procedures.

We know that leachate is formed in land disposal sites and that this liquid enters groundwater aquifers. As rain water percolates through soil, it is more or less purified depending on the constituents of the leachate and the type of soil through which it flows. In areas of high water tables and high precipitation, there is a significant potential for groundwater contamination. The extent and seriousness of this problem is now being investigated, but a current presumption of damage exists.

A number of causes for inadequate waste management have been cited (e.g., municipalities have no money, technology is inadequate, trained manpower is lacking). However, EPA believes that these problems could be overcome if a major national commitment were made to control the adverse effects of waste management. Such a commitment would result in adequate standards and their vigorous enforcement. In turn, fiscal and other barriers would fall or be minimized.

EPA has formulated two strategic goals: to achieve acceptable and safe waste management, and to conserve natural resources. EPA is constrained in effectively formulating and implementing this strategy primarily by a lack of direct regulatory power to assure proper land disposal or groundwater quality protection. Authority to set standards on hazardous wastes has been sought from Congress.

EPA can (1) stimulate regulation by others, (2) provide limited planning support to States, (3) carry out research, development, and demonstration, and (4) provide technical assistance.

A. *Environmental Protection*

The strategy to achieve environmentally acceptable, safe solid waste management relies primarily on the eventual establishment of a regulatory approach. It is the most *direct* attack on environmental, health, and associated problems. The approach is to direct the most dangerous types of wastes to a limited number of strictly controlled processing/disposal sites, leaving a larger number of sites to process and dispose of less hazardous wastes.

This strategy relies heavily on the States. From the State perspective, the problem is one of *land disposal.* States generally have the power to issue regulations for all wastes and all sites and to relate the degree of control to the potential degree of hazard. Typically, however, States have issued site regulations that prohibit acceptance of hazardous wastes. The exclusion of certain wastes from disposal sites has virtually resulted in no controls for these excluded wastes. State enforcement of these regulations is severely hampered by low resources. A principal objective of the strategy is to strengthen the State role, particularly with regards to establishing authority over the disposal of all wastes. Adequate disposal site control also implies control of the *movement* of at least hazardous waste from generator to disposal sites lest indiscriminate dumping take place.

The major headquarters thrust will include: developing a data base on hazardous wastes; demonstration programs to advance certain treatment and disposal methods; developing a hazardous waste regulatory strategy; augmenting knowledge on the inter-media effects of land disposal; consolidating technical/economic data on all aspects of solid waste management; and technical assistance support to improve local practices.

B. *Conservation*

The approach to natural resource conservation by waste recovery and source reduction relies primarily on technical assistance. The primary barriers to waste recovery implementation are institutional constraints.

The plan is to concentrate on the evaluation and dissemination of information about existing systems to reduce perceived risk, and on working with communities seriously considering recovery options, helping them make sound decisions.

Headquarters will conduct a program of studies related to the concept of conservation through source reduction, primarily addressing benefit/cost trade-offs of economic product regulation.

Some States have emerged as strong supporters of recovery system implementation, primarily through the provision of financial assistance. Connecticut has a unique program in that it addresses institutional problems through a Waste Management Authority. The Authority puts together a package (site, system, financing backed by State bonding, contracts with firms to operate the system) for a competitive disposal fee, which covers the full cost of the system. This concept is attractive for disposal sites, as well as for resource recovery. The approach is to utilize Federal demonstration funds in one or more States to stimulate establishment of similar institutions.

C. *Regional Activities*

The Agency approach anticipates a strengthening of the role of EPA Regional Offices primarily to (1) provide better and more intensive relationships with States to help achieve national objectives; (2) to support enforcement efforts by States and to utilize existing enforcement powers where appropriate, and (3) to become the cutting edge of technical assistance efforts for waste management and resource recovery.

The headquarters role in support of the regions is to (1) provide policy guidance, (2) assess specific approaches taken by the Regions; (3) develop the knowledge on the state-of-the-art of all types of waste management practices; and (4) provide the specialized expertise for technical assistance.

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D. *Basic Strategy Assumptions*

The Federal solid waste management program was originally established to improve solid waste management nationally through research, development, demonstration, training, and planning activities. The major focus of the program in the 1965–1970 period was on municipal waste collection, processing, and ultimate disposal activities; and on State, local, and regional planning. In the 1970–1973 period, the focus was broadened to resource recovery, support of regulatory activities by States, and investigation of hazardous waste management problems.

It is assumed that the program will continue to evolve in a generally regulatory direction related to waste *treatment* and *disposal* activities, while in the resource recovery activities the Federal role will consist of implementation stimulation through technical assistance, information dissemination, planning activities, and demonstrations.

In FY 1975, the program is expected to operate under an extension of the Solid Waste Disposal Act, as amended. However, passage of legislation incorporating the provisions of the proposed Hazardous Waste Management Act is expected ultimately.

II. **The Problem**

Waste management presents a spectrum of problems, from extreme health and environmental hazard to municipal management inefficiency. The extremely diverse nature of the wastes (dead animals, mercury-rich industrial sludges, dredge spoils, abandoned cars, septic tank pumpings, residential solid waste, infectious hospital wastes, demolition debris, feedlot wastes, etc.) and their manner of occurrence (in or near concentrations of population, in rural areas, etc.), means that the dimensions of waste management are very diverse. Any abstraction of the problem into categories is a dangerous oversimplification.

The problem cannot be disaggregated neatly into "hazardous" and "non-hazardous" components. Solid waste is *not* merely residential trash and food wastes. Such an oversimplification obscures the real situation. The early stress on municipal solid waste (by the program and by others) was because this waste is most apparent to concerned environmentalists and is easier to understand than the management of many closely related industrial, institutional, and agricultural residuals.

The basic problem is improper land disposal of wastes—all wastes—with adverse environmental consequences. Appendix B provides a more detailed discussion of this subject. A categorization, recognizing the fact that it oversimplifies the issue, follows:

- *Health and Environmental Effects Occur Under Five Headings*

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Water. Ground and surface waters can be polluted by land deposition of wastes. The problem ranges from contamination of waters by heavy metals and other toxic chemicals to introduction of organics and soluble gases (CO_2).

Air. Air pollution can result from incineration, open burning, or sublimation of chemicals at land sites; odors are also associated with processing and disposal facilities, especially with organic waste dumps and lagoons.

Health. Disease vectors arise from improper waste management and waste movement and disposal. The problem is associated especially with improper storage and collection of residential wastes in the inner city.

Land Use. Waste disposal alters soil biota and soil chemistry and thus affects future potential land use. For example, land contaminated by heavy metals cannot be used for food or feed crop production.

Human Safety is endangered in accidents during waste collection and at land disposal sites where hazardous wastes are handled. Migration of methane or carbon monoxide from land sites to confined areas can cause explosion or suffocation respectively.

- *Aesthetic and Other Problems* also accompany waste management, especially the following:

Litter, ugly accumulations, and uncontrolled dumping;
Adverse economic impact of disposal sites on land values—due to historically poor practice in management of disposal sites;
Inequitable population effects—disposal sites typically impact on a small portion of the population but serve the total population; and
Inefficient management of wastes—which causes higher than required expenditures on this function by the people.

- *Resource Wastage.* Waste management is accompanied by little or no materials or energy recovery because recovery is most often more expensive than simple dumping. This activity is wasteful so long as simple dumping is an unacceptable practice for other reasons.

The resource aspect of waste management, however, goes beyond the fact that waste materials are not usually recovered. Waste generation is itself a symptom of national

practices that impact on the ability of the economy to supply materials and energy at requisite levels.

III. Major Causes of the Problem

The chief environmental problems exist for a number of interrelated reasons:

- *Regulatory and Enforcement Gaps.* Some States do not regulate disposal effectively and most do not enforce regulations vigorously because of low manpower resource commitments.

- *Resource Allocation.* Municipalities do not devote required resources to environmentally sound disposal and efficient management where such poor practice is tolerated by an apathetic population or where the impacted population has no political power.

- *Aesthetic vs. Environmental Control.* Since litter and ugliness are typically the most obvious target of popular displeasure, municipalities may manage disposal "cosmetically" but not environmentally — no blowing paper, no odor, but leachate into the groundwater — unless environmental regulations are enforced.

- *Barriers to Recovery.* Poor disposal practice is cheaper than resource recovery, and the cheap option retards the consideration of recovery or other more environmentally sound practices. In this connection, however, it should be noted that recovery today is primarily a residential/commercial waste management option and not a solution for *all* types of wastes.

  Especially acute is the effect of an absence of regulation in the industrial, and above all the hazardous waste areas, where the cost differential between dumping and proper treatment may be twenty-fold or greater. This results in under-utilization of the private sector industrial waste detoxification, treatment, and disposal services (the existing, small industrial waste management industry operates at 25 percent capacity).

  Typically a number of other "causes" for the problem are cited — e.g., municipalities have no money, disposal technology is inadequate, manpower resources are lacking or poorly trained, consultants are poorly qualified, etc. All of these are true to some extent somewhere. However, where a community makes a commitment to control the adverse effects of waste management, such problems can be overcome.

Absence of regulatory control (environmental standards, strictly enforced) is due to some of the following factors:

- *Ignorance of the Problem.* The problem has been identified recently. This is the case with highly hazardous wastes and with the potential of groundwater contamination by leachate. General recognition of the special nature of these wastes or effluents and their adverse effect on life and the environment is a recent phenomenon.

  Absence of Alternatives. Courts or regulatory agencies do not move against disposal site operators if there is no alternative available. Shut-down of an operation is impossible politically unless wastes can be placed somewhere else. Site operators can "blackmail" the public by threatening shut-down rather than expending resources for upgrading. This problem is closely linked with the next one, and is probably the chief obstacle to environmentally acceptable waste management where standards exist but are not enforced.

  Public Resistance to Disposal Type Land Use. Public resistance to the siting of a new disposal site is usually intense and flows from public knowledge of poor disposal practices in the past and reduction of land values (real or presumed). This makes creation of alternatives very difficult, prevents institution of the most economical logistical systems, and thwarts enforcement of regulations where they are in force.

  Imbalance in Power Between States and Large Metropolitan Areas. This phenomenon sometimes results in enforcement of regulations in small, rural places by the State but a "hands off" policy vis-a-vis large cities that have political and fiscal strength.

  Absence of Proven/Tested Technology. This phenomenon is applicable especially for hazardous waste disposal sites. It is difficult to mandate, for instance, the disposal of pesticides in landfills without hydrological connections unless such sites exist. It is difficult to establish such sites without the necessary engineering and testing programs to identify appropriate designs and to ascertain their viability. To a lesser extent, this issue also retards recovery of some types of resources — e.g., nonferrous metals and glass.

IV. Strategic Goals

From the problem statement the following goals are formulated for solid waste management:

- Achieve acceptable and safe waste management to protect public health and welfare and the environment.

- Conserve natural resources through institution of resource recovery or by other means where economically feasible.

Acceptable and safe waste management (for environmental, health, and safety reasons) necessarily results in the elimination of most site-related land and groundwater pollution, litter and blight, should improve the land values around disposal sites, will minimize adverse inter-population effects, and (by imposing higher costs on disposal operators) will create incentives for fiscal efficiency and other environmentally acceptable options. Roadside litter, accumulations of abandoned automobiles or other bulky wastes, and similar littering without a health or environmental impact would not be addressed by this goal. Resource conservation would be indirectly aided by the achievement of this goal in that it would raise the costs of disposal and thus make higher cost recovery a better option.

Conservation through recovery and other means, while indirectly supported by environmental, health, and safety related upgrading of waste management, is singled out as a national goal because resource recovery is a new activity at this time, not yet a self-evident waste management option. Institution of recovery systems (or other measures) will require more than regulatory pressure to achieve. Achievement of the highest feasible recovery is seen as a worthwhile national goal for national efficiency, strategic, and general public welfare reasons — to forestall shortages and disruptions attendant on shortages.

Both *national* goals are appropriate *Federal* or *EPA* goals. Environmental and health protection is the chief mission of EPA. Resource conservation is the mission of the FEA (for energy) and of Interior (for minerals). Conservation of materials and energy from *waste* can and should properly be an EPA mission in that the achievement of such recovery is inextricably intertwined with considerations of waste management and ultimate disposal and achievement of environmental and conservation objectives are mutually supportive.

V. Constraints to Strategy Formulation

A. *Regulatory Power.*

There is no Federal regulatory power directly applicable to all land disposal sites and land disposal practices. The Federal Water Pollution Control Act does address the issue of land application systems for the treatment of municipal wastewater. The Clean Air Act is fairly effective in addressing problems from open burning. But no effectively clear control over groundwater exists for the many other kinds of wastes and disposal practices. Control over surface water pollution from disposal sites is weak. Section 209 of the existing Solid Waste Disposal Act provides the authority to issue guidelines which are mandatory for Federal

agencies but no one else. Until regulatory power is provided to the Agency, work will be carried out under the authority and mandates of Section 209.

B. *Knowledge.*

The extent of systematic knowledge (suitable for broad trade-off analysis and regulatory program justification) is relatively poor. This is especially true with regard to (1) industrial hazardous (and not-so-hazardous) waste quantities and compositions as they actually occur; current data are in the form of chemicals, not chemicals in actual waste streams; (2) land, air, water inter-media consequences of various types of disposal, (3) the effect of hazardous and toxic materials on plant and animal life, (4) hazardous waste treatment and disposal technology, and (5) the qualities, nature, occurrence, and handling methods related to numerous special wastes not heretofore given priority (crop wastes, animal wastes, hospital wastes, demolition debris, dredgings, and a variety of nonhazardous or "situationally" hazardous sludges, (6) treatment and processes of the consequences of the use of the land as a disposal media, and (7) the costs and benefits of product regulation for recovery or source reduction.

C. *Diversity.*

State and municipal government structures, philosophies, and procedures vary greatly from region to region and within regions. Differences in geography, geology, population density, and many other factors exist. A uniform strategy for all States or all wastes or all regions is unrealistic and probably counterproductive.

VI. Tools

Basic tools that could be used to achieve the strategic goals are listed below. Not all of these are available under existing authorities.

- *Regulatory action* at various levels (Federal, State, local) including combinations such as Federal standards, state enforcement, local implementation, etc. This includes the semi-regulatory use of guidelines and recommended procedures. Land condemnation procedures would fall into this category.

- *Fiscal support* such as grants, loans, subsidies, tax credits (to various levels of government and various types of organizations for a diversity of purposes) designed primarily to support capital acquisition and/or operations. This category could include provision of land as a fiscal support mechanism.

- *Research, development, and demonstration*, in-house or through contracts and grants, aimed at systems development and testing and environmental, health, and safety assessment.

- *Technical assistance*, consultation, and other forms of communications to transfer knowledge, to facilitate project or program implementation, to persuade others, etc.

VII. Discussion of Basic Strategic Approach

A general strategic approach to achieve the two goals formulated above is presented and discussed here. A program array for the period of this strategy assessment is presented in the next section.

A. *Strategy to Achieve Environmentally Acceptable and Safe Waste Management, and Protect Public Health*

The basic elements to achieve this strategy include:

(1) Regulatory control of waste storage, treatment and disposal.

(2) Mixed Federal and State implementation based on degree of harm associated with types of wastes.

(3) Program thrust supported by fiscal support to States, R&D, demonstrations and technical assistance.

(4) Direct regulation and enforcement relative to Federal facilities.

Discussion. A regulatory approach is the single strategy likely to achieve a number of ends as discussed earlier. If consistently followed over a period of time, it moves toward the most equitable distribution of the costs of control, provides for maximum participation by the private sector, provides incentives for efficiency and thus for cost reductions, and represents the most direct attack on environmental, health, and associated safety problems.

Significant differences in environmental and health damage are associated with types of waste, from innocuous (glass bottle) to severe (arsenic-containing pesticide). The level of attention that should be paid by the Federal government to waste management can be related to the degree of harm involved, the inter-state or national extent of damages resulting from poor management, etc. Given the ever-present resource constraints it is logical to some extent to concentrate Federal action in those areas where waste management problems have the most direct adverse impact.

General Approach. The approach is to direct the most severe types of wastes to a few, strictly controlled processing/disposal sites, leaving the overwhelming number of other sites to process/dispose of other wastes. Thus the above strategy envisions a "cascading" regulatory strategy with direct Federal regulation and enforcement of very hazardous wastes, Federal standard-setting and state implementation of other hazardous wastes, and State responsibility for "other" wastes guided by Federal guidelines.

It is stressed that a clean demarcation between "hazardous" and "non-hazardous" wastes does not exist except at the extremes of the spectrum. As more experience is gained the basic strategy is expected to change as well and reflect the gaining of clearer views of the demarcation.

Federal Facilities. The chief exception to this general strategy is waste management on Federal facilities which is controlled under Sections 209 and 211 of the Act and Executive Order 11752. Relative to these sites, the strategy is development and direct enforcement of Section 209 guidelines (mandatory for Federal agencies) together with the necessary supporting technical assistance and administrative efforts.

State Role. This strategy relies heavily on State implementation of a Federal hazardous waste regulatory program and on a vigorous State regulation and enforcement of "other" waste management. This strategy envisions strengthening the State role through fiscal support on a flexible basis for both enforcement and for other preparation for a greater hazardous implementation role. Thus, EPA is attempting to "strengthen the State role" in all aspects of waste management.

From the State perspective, the problem is one of *land disposal.* States generally have authority to promulgate regulations for disposal sites and to relate the degree of regulation to the potential degree of hazard. Many States have issued regulations only for sites that receive non-hazardous wastes; a few have regulations promulgated for both. First, States that do not have the power to issue disposal regulations should acquire that capability. Second, States that have general authority should issue regulations. Third, States that have issued regulations should implement them, emphasizing the establishment of hazardous disposal sites separate from sites for other wastes where needed, available in proximity to the major waste generators. Thus, to "strengthen the State role" implies more aggressive use of existing State permit, site approval, and enforcement powers—particularly with regards to using existing legislation to develop stricter criteria for hazardous waste disposal sites, distinct from "other" sites. Finally, States must take a more aggressive role in regulating all sites.

States can get ready for the control of hazardous waste. Current EPA concepts rely on a waste stream-by-stream approach to direct the worst wastes to selected sites and requires generators to show the disposition of their wastes. Few States have the authority to place

similar requirements on generators, and none have implemented authority (although the NPDES does provide some leverage). States that do not have this power should obtain authority; those with authority should implement it. As a first step, this approach implies that States should obtain knowledge of generators of wastes, and present management practices.

States can act to provide a facilitating role (apart from the incentives which result from appropriate enforcement) for desirable practices if the State desires—for resource recovery, hazardous waste disposal, or municipal waste disposal. Actions may include State involvement in local siting actions, use of State eminent domain powers, implementation of low cost, self-financing concept. The Connecticut Authority appears to be an attractive approach to address institutional and financial constraints in disposal, as well as in resource recovery.

To achieve the strategy, EPA will use its existing authorities to support planning and demonstration activities at the State level that (a) achieve progress toward hazardous waste control, (b) increase the pace of standard-setting and enforcement relative to "other" wastes, and (c) lead to the establishment of facilitating institutions for implementation of resource recovery and hazardous waste treatment facilities.

It is recognized that the States will require some incentive for stepped-up action. Current authorities limit the range of Federal influence over State action. However, it is assumed that a Federal standard-setting role will emerge from the current legislative cycle, which would require state implementation. Failing that, EPA will depend on persuasion and fiscal support for carrying out the strategy.

Hazardous Waste Technology and Effects. Because the level of knowledge is very low about control technology and effects of hazardous wastes, and because the Federal government will require hard data for standard-setting, a R&D and a demonstration element is absolutely necessary as a means of developing and justifying standards.

"Other" Wastes. In the "other" waste areas, the level of knowledge about the environmental and health effects associated with the many waste streams (animal, crop, and mining wastes; industrial slags; septic wastes; dredge spoils; various sludges and residues; and urban waste mixed or disposed of in combination with special wastes) is inadequate—particularly inter-media effects, effects on ground and surface waters, relationships between types of soils and leachate generation, etc. This strategy envisions investigations to obtain such understanding to guide better the assessment of Federal strategies in the future.

B. *Strategy to Conserve Natural Resources by Waste Recovery and Source Reduction*

The basic elements to achieve this strategy include:

(1) Technical assistance to promote implementation of energy and materials recovery systems.

(2) One-time state recovery program support.

(3) Limited demonstration of technology to enlarge the technical options.

(4) Investigation of cost/benefit aspects of product regulation and other source reduction methods.

Discussion. The fundamental barriers to implementation of waste recovery are (1) institutional constraints arising from the need to form novel institutional arrangements to practice recovery and (2) the high risk associated with full scale demonstration of new technology, which prevents demonstration of such technology with private or State/local funds.

EPA analyses indicate that resource recovery is already economically feasible in many areas, will become more so as regulatory thrusts are initiated, and is not impeded by fiscal constraints (State, private, and municipal funds are available).

The ability of the consulting community to provide technical aid and consultation is severely limited — largely by the fact that new systems are proprietary and the basic information is Federally held (in demonstrations). Thus this strategy envisions a two-fold thrust — to provide technical assistance to communities and States and to improve the ability of the consulting community to provide services.

Some States have emerged as strong supporters of recovery system implementation: Connecticut, for instance, with Federal support, established a state-wide plan, an independent authority with funding powers ($250 million in bonding authority), and a strong state regulatory program (to foreclose cheap options). The state-wide scale provided by such programs, the State financing potentially available after an initial planning/implementation effort, and the ability to establish large and intelligently located facilities (that provide needed specialized as well as general purpose facilities) indicates that the State role in recovery can be strengthened by intelligent use of Federal resources.

Measures to reduce the generation of waste in essence represent changes in products and distribution systems undertaken either voluntarily or by legislative fiat. Such interventions,

unless minor, tend to be associated with costs to the economy in terms of disruption (jobs lost, equipment obsoleted, locational shifts, etc.) and must be carefully weighed against benefits. The benefits are reduced pollution, conservation of raw materials, and avoidance or minimization of the disposal function. Because the benefits of reduced consumption (achieved through less materials-intensive or longer-lived products or through substitution of reusable for one-time-use products) are very significant, assessment of such conservation options is a key part of the EPA strategy. However, because of the great variety of products that must be examined, the approach will be selective, targeted to products or product categories that promise the most success of achievement at lowest cost.

VIII. Summary of Programmatic Implementation

Through FY 1975, the following program thrusts are envisioned to carry out the strategies broadly described above. The programs are arranged in order of priority within each major goal area and are presented in categories that group related activities as closely as possible.

SUMMARY OF PROGRAM THRUST

A. Environmental Protection

1. Prepare for a hazardous waste regulatory role

   a. Develop the data base—health/environmental effects, quantification/qualification of waste streams, treatment/disposal technology
   b. Develop a regulatory strategy—type of standard, State role, fiscal and land-use issues
   c. Strengthen States to implement a hazardous waste role
   d. Implement Section 19, FIFRA

2. Support Federal/State/local efforts

   a. Develop technical expertise in special wastes
   b. Consolidate/augment technical knowledge or inter-media effects of land disposal
   c. Consolidate/disseminate technical/economic data on processing and disposal methods
   d. Support State regulatory/enforcement programs

e. Implement Section 209 guidelines at Federal Facilities
f. Other (complete demonstrations and provide technical assistance)

B. Resource Conservation

1. Promote implementation of energy recovery from mixed urban wastes

a. Technical assistance to States, localities, and the private sector
b. Operation and evaluation of projects—EPA demonstrations and others—to support TA thrust
c. Support of selected State implementation programs
d. Identification and demonstration of new technological concepts

2. Promote materials recovery through technical assistance and information exchange in the establishment of separate collection/recycling programs

3. Conduct a program of studies related to the concept of conservation through source reduction

a. Benefit/cost trade-offs of economic product regulation
b. Development and dissemination of information to foster voluntary source reduction practices

4. Promote the consumption of secondary materials through Federal procurement and other actions

(Excerpted from: H. Lanier Hickman, Jr., comp., Activities of the Office of Solid Waste Management Programs, Fiscal Year 1975: Annual Report. /Washington/ U.S. Environmental Protection Agency, 1975.)

II. OSWMP FY 75 PROGRAM PERSPECTIVE

The Office of Solid Waste Management Programs is a small program in the Environmental Protection Agency. It consists of a staff of 125 and in Fiscal Year 1975 had a base budget of about $12.3 million. Additional funding received subsequent to approval of the base budget raised the total amount of dollars managed by OSWMP in 1975 to approximately $20 million. Other portions of the Agency, the Office of Research and Development and the 10 EPA Regional Offices also are involved in solid waste management.

The OSWMP is not a regulatory program. The existing Solid Waste Disposal Act, as amended, was extended in FY 75. Several hearings were held on substantive amendments to the present Act but new legislation did not pass either the House or the Senate.

A major accomplishment in Fiscal Year 1975 was the publication of an Agency solid waste management strategy in October 1974. This strategy statement gives the priorities for the Agency's solid waste management efforts, and details the programmatic thrusts of the program. The Agency goals as stated in the solid waste management strategy are to achieve acceptable and safe waste management, and to conserve natural resources.

To meet these goals the Office is attempting to develop a better understanding of the environmental problems caused by improper management of certain wastes that may be "potentially hazardous." Our Hazardous Waste Management Division (HWMD) focused on this effort. HWMD is establishing a data base to understand the sources of wastes (mostly industrial sources), the potential environmental damages that are or may be caused by improper management of those wastes, and the technology options that may be applied or be needed to reduce or eliminate potential damages. Major studies are underway in 13 industry groupings in the U.S. to define quantitatively and qualitatively thir hazardous waste streams. A large study is underway to test the acceptability of various thermal reduction processes to destroy certain hazardous wastes and a major project to demonstrate the land disposal of chemical (hazardous) wastes was initiated in FY 75. This Division is also developing the necessary tools and capabilities necessary to enable hazardous wastes to be regulated to protect environmental quality and public health. Studies are underway to interpret and understand other environmental regulatory programs and to develop recommended procedures for hazardous waste management. This Division has been delegated the responsibility to issue disposal regulations for pesticides and pesticide wastes under the FIFRA, as amended. This Division also works with the States and others who are developing their own regulatory programs directed toward "potentially hazardous" wastes. Major program elements of HWMD are guidelines development, data base development, and program implementation. Major projects in the HWMD are described under these headings in Section III of this report.

A major focus of the Systems Management Division (SMD) is the development of a better understanding of land disposal practices for wastes. In the past, OSWMP focused primarily on land disposal for municipal solid wastes, but during FY 75 increased resources were devoted to understanding the effects and practices of disposal and/or utilization of municipal sewage sludge on the land. SMD is supporting the Water Supply Office of EPA by preparing a Report to Congress, as required by the Safe Drinking Water Act, on the impacts of all land disposal practices on groundwater. Our land disposal efforts are to characterize the nature of leachate generated and potential or actual groundwater contamination from a variety of land disposal practices, to understand the technology of leachate collection and treatment, and to work with communities to better implement sound waste disposal practices. SMD has initiated a project to demonstrate anaerobic treatment of leachate and has underway a project to determine the acceptability of utilizing municipal sewage sludge as a soil conditioner and supplement in growing turf. This Division also addresses conventional solid waste management; with significant efforts directed toward the promotion of collection efficiency and safety in solid waste management. Of particular interest is the technical assistance capability and supportive tools of SMD which when utilized by cities and industries can significantly reduce their collection costs. SMD is also developing guidelines for the collection of municipal, commercial and institutional solid wastes under Section 209 of the Solid Waste Disposal Act, as amended. Major program elements of SMD are technical assistance, land disposal and special wastes. Major projects in the SMD are described under these headings in Section III of this report.

A major focus of the Resource Recovery Division (RRD) is the implementation of systems to recover energy and materials from solid waste. RRD currently manages 5 large resource recovery demonstration projects, (two in materials recovery and 3 in energy recovery) and is attempting to stimulate the adoption of systems to separate wastes at their generation source for separate collection and recovery. RRD devotes considerable effort in studies and analyses to determine what actions are needed to stimulate increased demands for secondary materials and increase the practice of waste reduction. RRD also is responsible for the preparation of the annual Report to Congress on Resource Recovery and Waste Reduction as mandated by Section 205 of the Solid Waste Disposal Act, as amended. This Division is also responsible for developing 4 guidelines for resource recovery under Section 209 of the Solid Waste Disposal Act, as amended. These guidelines address the sale of returnable beverage containers at Federal facilities, source separation and separate collection of wastes for recycling; implementation of large scale resource recovery facilities to recover materials and energy; and Federal procurement of products containing material recovered from post consumer wastes. Major program elements of RRD are materials recovery, energy recovery, and waste reduction. Major projects in the RRD are described under these headings in Section III of this report.

During FY 75 $3.0 million was allocated to the Agency's Regional Offices to fund planning, demonstration and training projects of State solid waste management programs. The Regional Administrators were allowed maximum flexibility in awarding grants to State programs in order to implement the State role as envisioned in the Agency's Solid Waste Management Strategy for FY 75.

Grant funds were utilized by the State solid waste management programs to increase efforts in the enforcement of State regulations for solid waste processing and disposal facilities, to initiate State-wide hazardous waste surveys, and to conduct the planning necessary to encourage material and energy recovery from solid waste.

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(Excerpted from: U.S. House of Representatives, Committee on Interstate and Foreign Commerce, Waste Control Act of 1975, Hearings, April 8-17, 1975. Washington: U.S. G.P.O., 1975.)

STATEMENT OF DR. THOMAS V. FALKIE, DIRECTOR, BUREAU OF MINES, DEPARTMENT OF THE INTERIOR

Mr. Chairman and Members of the Committee, thank you for asking me to participate in these hearings and to discuss with you our views on solid waste management. We have always supported the twin objectives of increased recycling of wastes and improved waste disposal practices. In our view, secondary resource recovery is not only desirable as a means of augmenting our primary supplies of raw materials, but is also essential from an environmental standpoint to reduce the ever-increasing volumes of wastes that must be disposed of.

Since its creation by the Congress in 1910, the Bureau of Mines has been concerned with recycling mineral-processing wastes and with the refining of secondary metals such as lead, zinc, copper, and brass. In recent years, we have focused attention on recovering metals and minerals from urban refuse and a variety of industrial wastes, and on devising methods for more effectively processing junk autos to encourage more complete recycling of the metals and nonmetallic constituents. I would like to describe what is being done and what can be done to assure more effective reuse of these wastes.

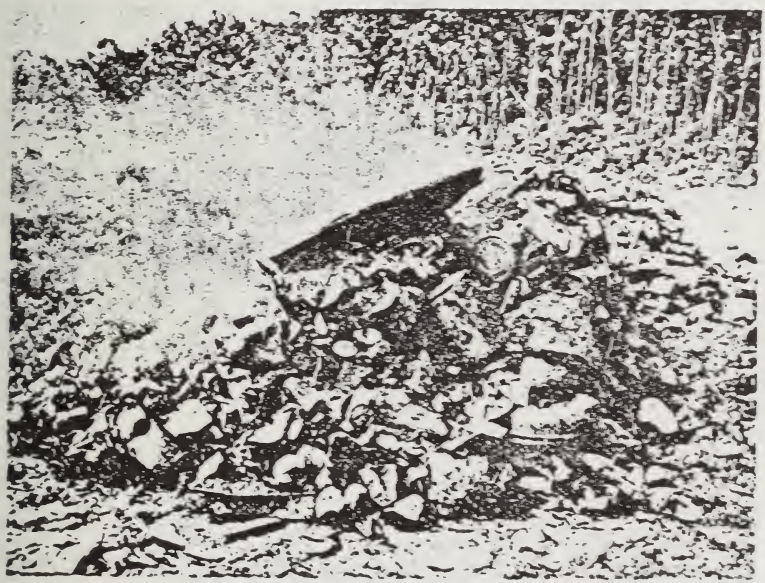


FIGURE 1.—Municipal incinerator residues.

TABLE 1.—URBAN REFUSE GENERATED BY THE UNITED STATES

	Millions of tons	Estimated scrap value (millions)
Collected and disposed of annually by cities	125.0	
Containing:		
Ferrous metals	9.0	$360
Nonferrous metals (aluminum, copper, zinc)	1.3	405
Glass	12.0	240
Combustibles	94.0	375
Total		1,380

Urban refuse is a rich potential source of recyclable minerals and metals. According to the Environmental Protection Agency, about 125 million tons of refuse—comprising household, commercial, and some industrial wastes—are collected and disposed of yearly by our cities and municipalities (table 1). These wastes contain 9 million tons of iron and steel, more than 1 million tons of nonferrous metals, about 12 million tons of glass, and over 90 million tons of combustibles. The heating value of the combustibles is equivalent to about 45 million tons of coal, or more than 200 million barrels of oil per year, which could reduce our dependency on interruptible and high cost fuels from abroad. The estimated gross value of the recoverable materials in the refuse is $1.4 billion.

Two processes have been developd in our laboratories for recovering the valuable materials from the refuse. One process is applicable to incinerated refuse and the other to treatment of the raw refuse. Both processes employ simple techniques and equipment that have been used in the minerals processing industry for many years in recovering metals and minerals from their ores. Bureau of Mines metallurgists have taken these techniques and equipment and adapted them for the job of waste prevention.

INCINERATOR RESIDUE TREATMENT

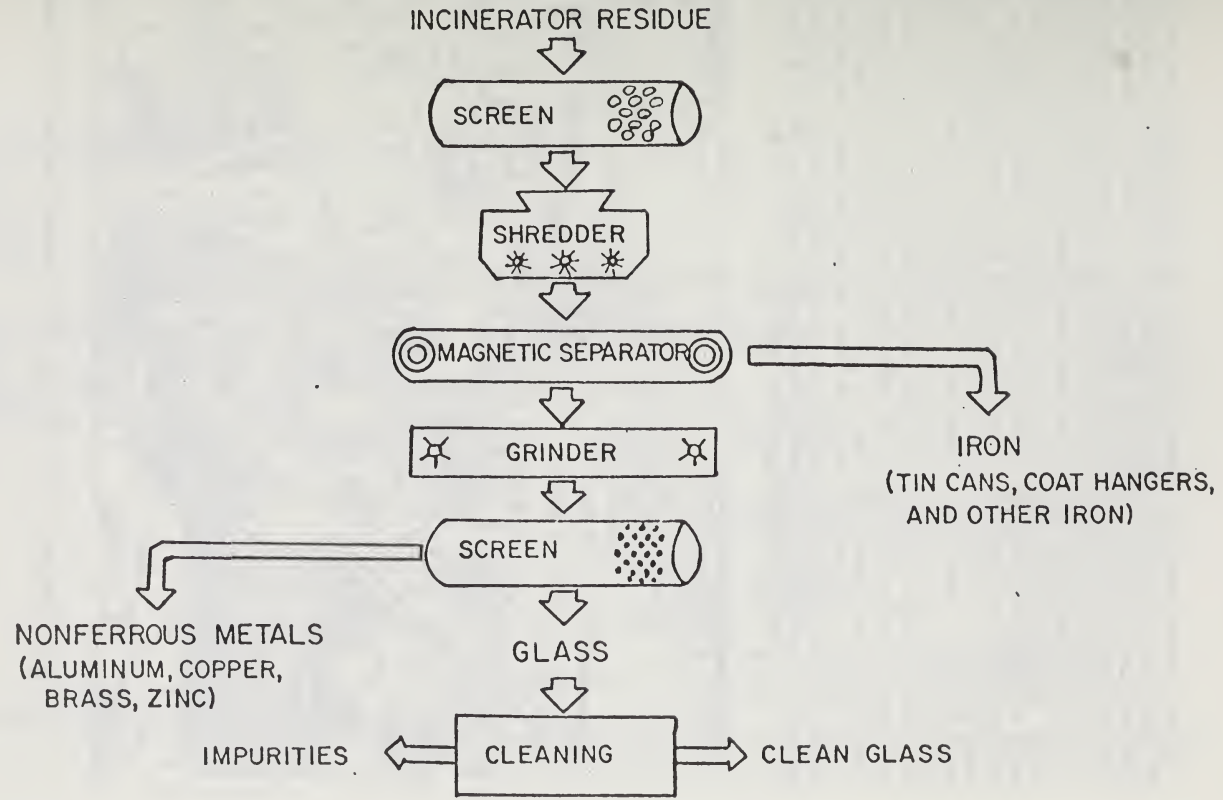


FIGURE 2.

Of the refuse generated, about 30 million tons are currently burned in some 200 municipal incinerators operating through the United States. Incineration is expensive, but it serves to reduce the volume of the refuse by some 90 percent. Thus substantially less land space is required for disposal of incinerated refuse (incinerator residues), than for raw refuse. The incinerator residue is like a mineral ore, containing iron, glass, and nonferrous metals such as aluminum, copper, lead, and zinc (figure 1). These components are readily separated by a series of screening, grinding, jigging, and magnetic separation steps, as shown in figure 2. The process has been developed in a pilot plant, capable of treating about 12 tons of residue daily, which the Bureau has been operating at its Metallurgy Research Center just outside of Washington, at College Park, Maryland (figure 3). This process will be demonstrated in a plant having a daily capacity of 250 tons of residue. The plant is being constructed by the city of Lowell, Massachusetts, on a cost-sharing basis with funds provided by the Environmental Protection Agency, and will treat the residues from several incinerators in the Lowell area. On the basis of extensive tests in our pilot plant, we estimate that recovery of the metals and glass from incinerator residue can provide a net credit, exclusive of marketing, transportation, and other indirect costs, of almost $15.84 per ton of incinerator residue processed (table 2).

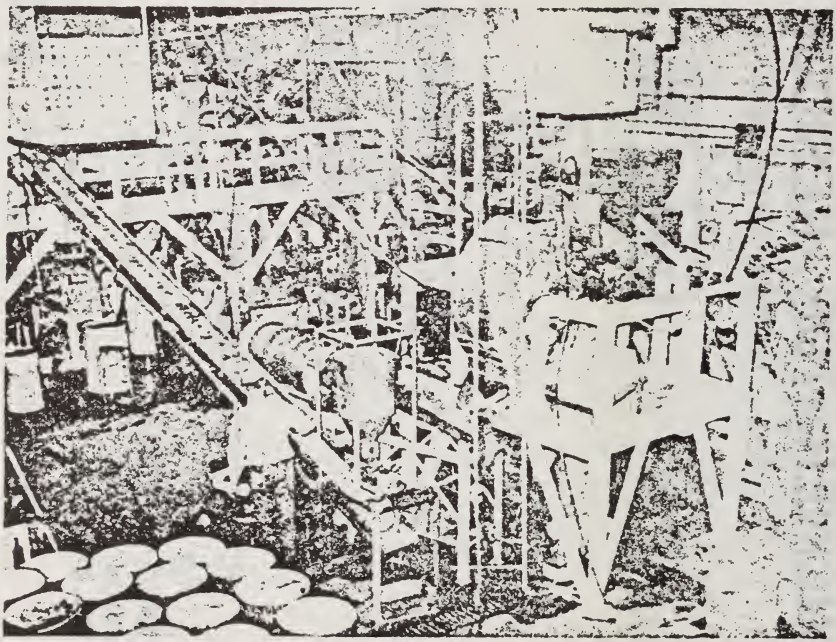


FIGURE 3.—Bureau of Mines' incinerator residue recovery plot plant

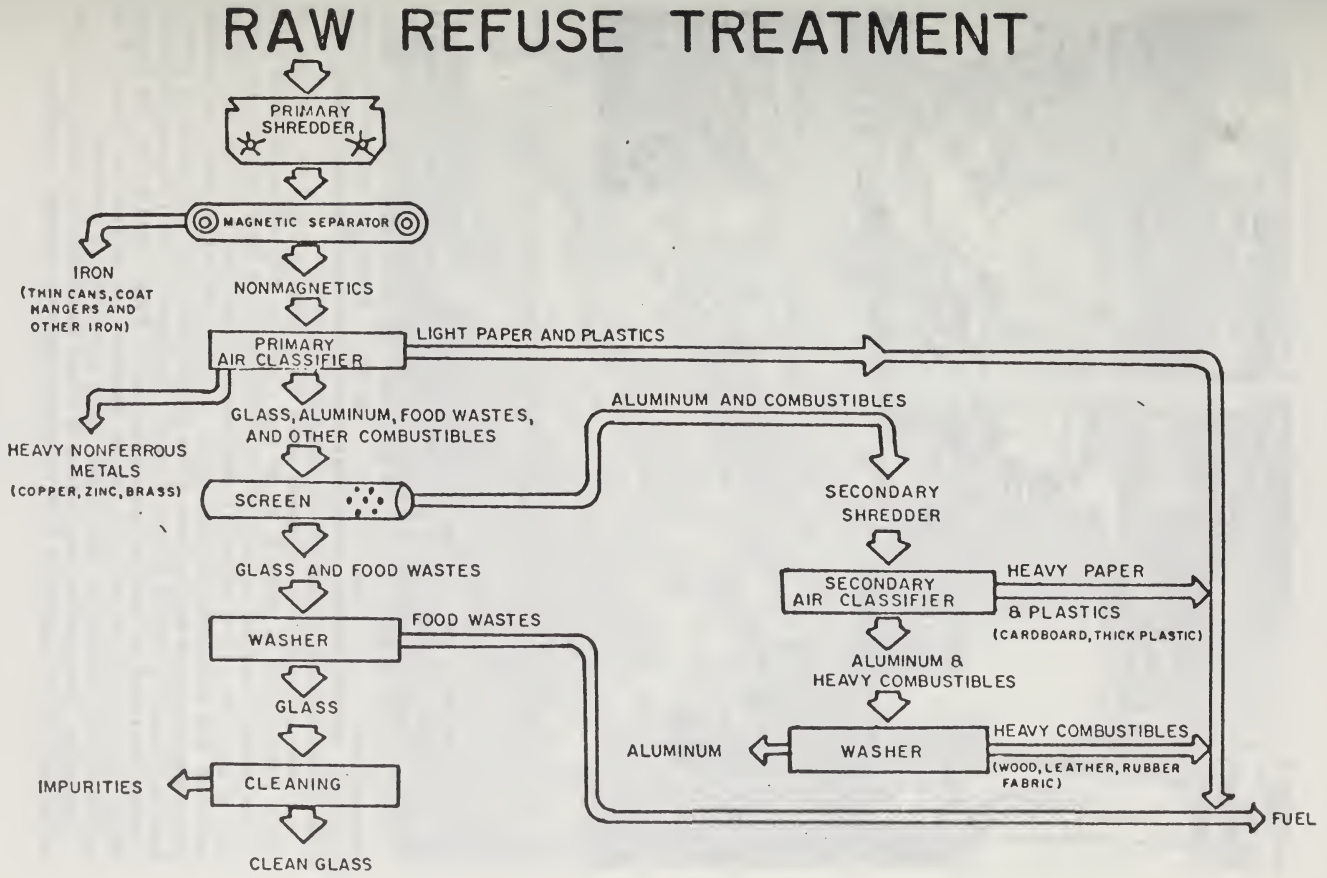

RAW REFUSE TREATMENT
PRIMARY SHREDDER
MAGNETIC SEPARATOR
IRON
(THIN CANS, COAT HANGERS AND OTHER IRON)
NONMAGNETICS
PRIMARY AIR CLASSIFIER
LIGHT PAPER AND PLASTICS
HEAVY NONFERROUS METALS
(COPPER, ZINC, BRASS)
GLASS, ALUMINUM, FOOD WASTES, AND OTHER COMBUSTIBLES
ALUMINUM AND COMBUSTIBLES
SCREEN
SECONDARY SHREDDER
GLASS AND FOOD WASTES
SECONDARY AIR CLASSIFIER
HEAVY PAPER & PLASTICS
(CARDBOARD, THICK PLASTIC)
WASHER
FOOD WASTES
ALUMINUM & HEAVY COMBUSTIBLES
GLASS
ALUMINUM
WASHER
HEAVY COMBUSTIBLES
(WOOD, LEATHER, RUBBER FABRIC)
IMPURITIES
CLEANING
FUEL
CLEAN GLASS

FIGURE 4.

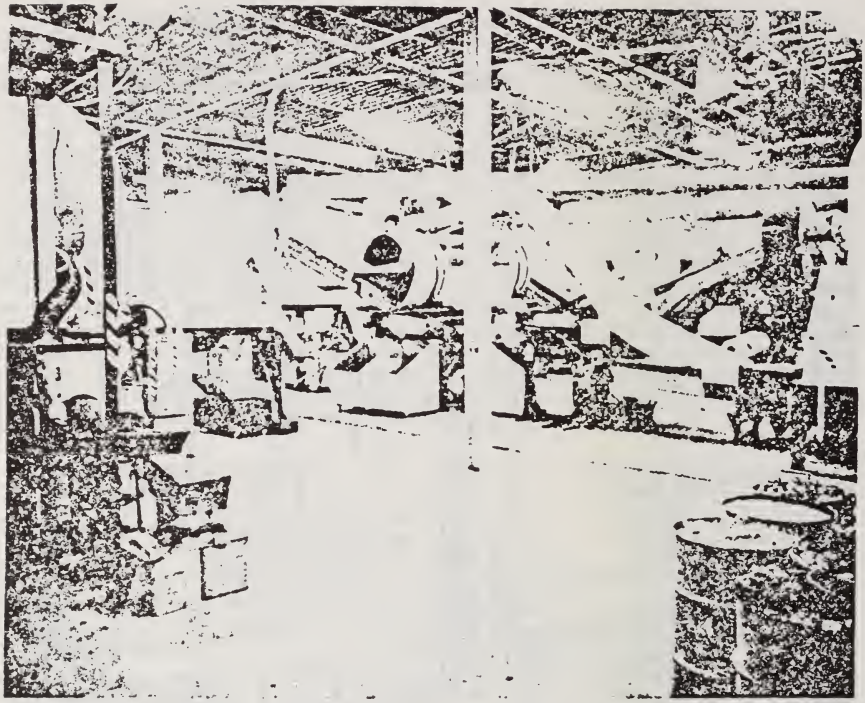


FIGURE 5.—Partial view of raw refuse separation pilot plant.

Nationwide, most refuse—amounting to about 95 million tons per year—is not incinerated but disposed of in landfills. Treatment of this raw or unburned refuse with techniques developed by the Bureau of Mines yields a combustible fraction as well as metal and glass products (figure 4). This process is being demonstrated in a pilot plant having a capacity of 5 tons per hour which is operating at our College Park Metallurgy Research Center. Figure 5 shows a view of the plant, and typical feed material appears in figure 6.

Our tests indicate that operating costs for a plant processing 1,000 tons of refuse daily would be about $2.70 per ton (table 3). The estimated gross value of the product obtained in such an operation would be $10.91 per ton, netting a gain of $8.21 per ton of refuse. In addition, $3.00 per ton in landfill costs would be saved. The processing system (figure 7) has attracted national and international attention, and adaptations of the process have been announced by several local governments, such as Monroe County (Rochester), New York, and Baltimore County, Maryland, as well as the governments of France and Spain. The Bureau offers technical assistance to all parties interested in applying all or part of the system to the solution of their solid waste management problems.

Technology developed by the Bureau of Mines and others has stimulated widespread activity to implement solid waste management through recycling.

FIGURE 6.—Raw refuse entering Bureau of Mines' resource recovery pilot plant.

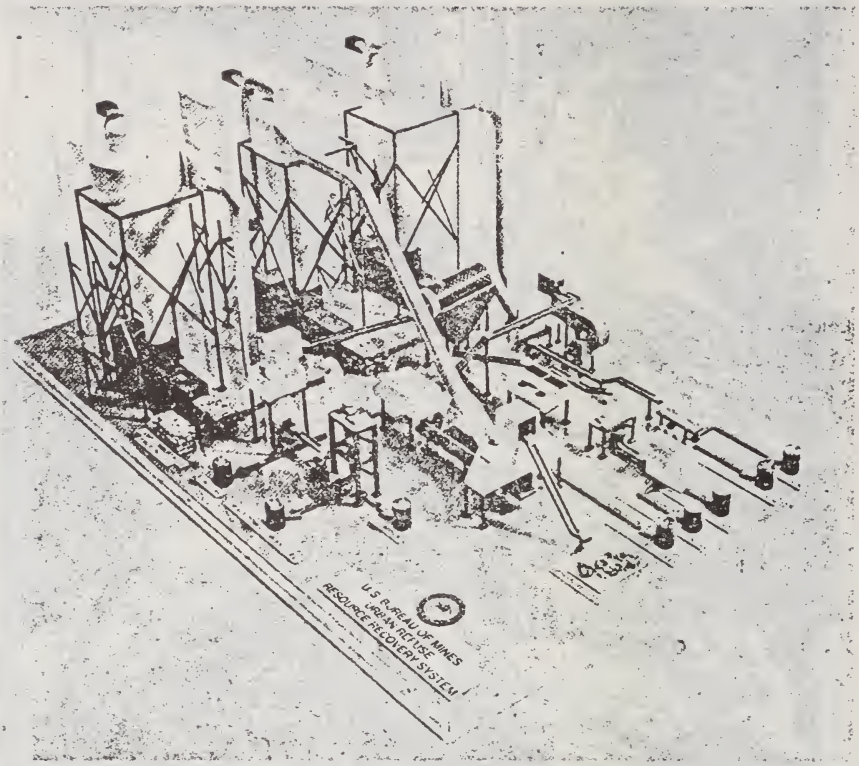


FIGURE 7.—Model of 1,000-ton-per-day raw refuse resource recovery plant.

TABLE 2.—PRODUCTS IN 1 TON OF INCINERATOR RESIDUE

Product	Pounds	Estimated scrap value
Ferrous metals	400	$6.00
Aluminum	35	5.25
Copper, lead, zinc	15	6.00
Clean glass	600	6.00
Fine ash and slag	950	0
Gross value		23.25
Treatment cost (250 tons per day) [1]		−7.41
Net gain [2]		15.84

[1] Includes amortization of capital investment and depreciation of 5 percent over a period of 20 yrs.
[2] Exclusive of marketing, transportation, and other indirect costs.

TABLE 3.—PRODUCTS IN 1 TON OF RAW REFUSE

Product	Pounds	Estimated scrap value
Ferrous metals	144	$2.88
Aluminum	16	1.92
Copper, lead, zinc	4	1.20
Clean glass	188	1.88
Combustibles (fuel)	1,516	3.03
Waste (ceramics, dirt, etc.)	132	0
Gross value	2,000	10.91
Treatment cost (1,000 tons per day) [1]		−2.70
Net gain [2]		8.21
Saving—hauling and landfill		3.00
Total		11.21

[1] Includes amortization of capital investment and depreciation of 5 percent over a period of 20 yr.
[2] Exclusive of marketing, transportation, and other indirect costs.

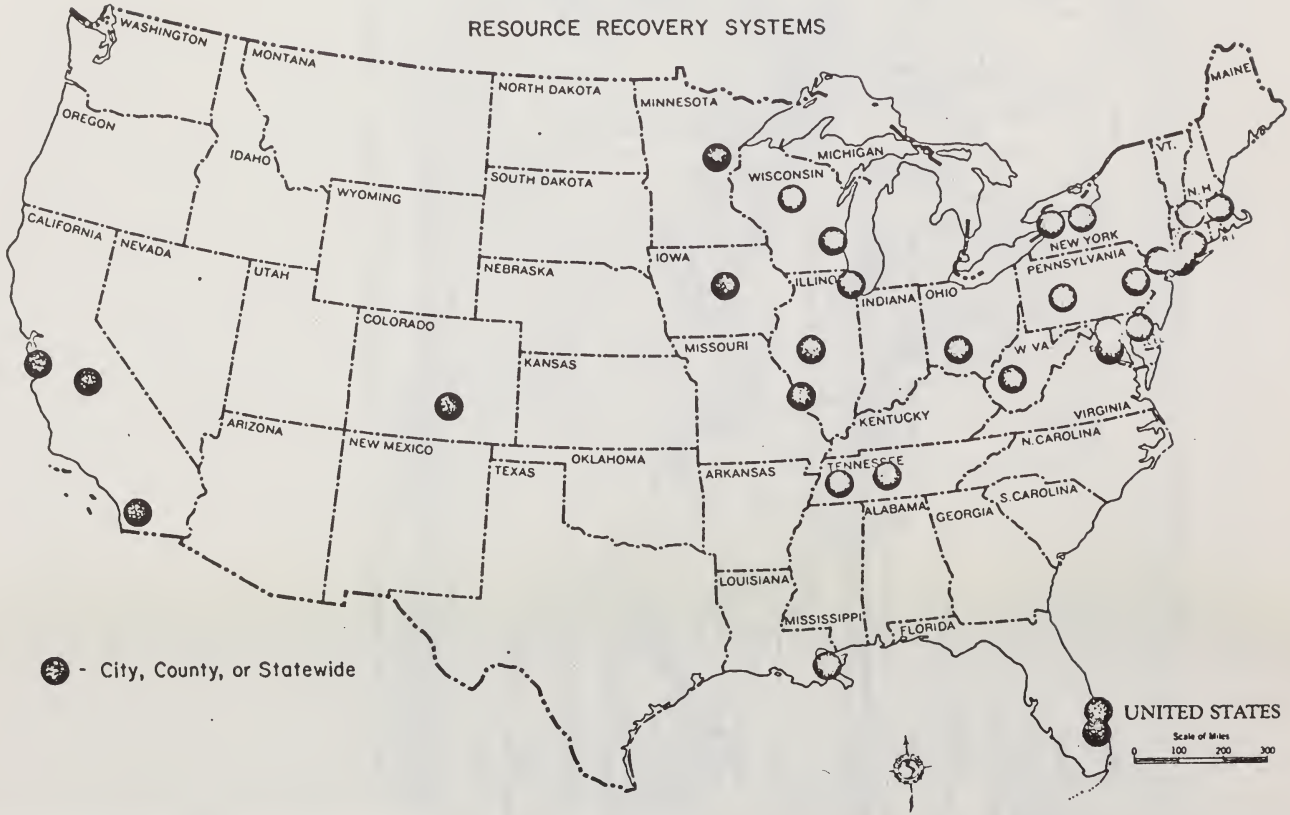

RESOURCE RECOVERY SYSTEMS
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
MICHIGAN
ILLINOIS
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
S.CAROLINA
N.CAROLINA
VIRGINIA
W VA.
PENNSYLVANIA
NEW YORK
MAINE
VT.
N.H.
- City, County, or Statewide
UNITED STATES
Scale of Miles
0 100 200 300

FIGURE 8

Figure 8 indicates the extent of demonstration projects and commercial installations planned, under construction, or operating on the State and local levels. The techniques being adopted include a variety of pyrolysis, fuel substitution, and materials recovery processes. Much progress has been made and we are sure that continued effort will lead to further advances in the future as the country progresses toward extensive practice of solid waste recycling.

Concurrent with work on urban refuse, we have been developing new and better methods for processing junked motor vehicles at our Salt Lake City (Utah) Metallurgy Research Center. About 9 million cars, trucks, and buses are junked annually here in the United States (table 4). Approximately 8 million of these vehicles are scrapped to recover the iron and steel: 4 million by shredding and 4 million by hand dismantling. However, a large proportion of the nonferrous metals and nonmetallic materials simply goes to waste. In addition, about 1 million junked vehicles per year are not recycled and instead enter an idle "inventory" estimated at between 12 and 20 million units.

One of the immediate problems faced by small-scale processors of junk cars several years ago was the promulgation of air quality regulations which prohibited the open burning of cars. Because burning is a vital step in the preparation of junk cars for hand dismantling and shearing or bundling, the Bureau developed an improved smokeless incinerator for automobiles which junk car processors can construct at minimal cost (figure 9). Currently there are more than 30 incinerators of this design operating in the United States.

Large-scale processors mechanically shred junk cars at a rate of 25,000 to 300,000 units per year to produce fist-sized chunks of metal.

TABLE 4.—JUNK CARS

	Weight, million tons [1]	Units, millions [1]
Vehicles junked	13.5	9
Vehicles shredded	6.0	4
Iron	4.5	
Nonmagnetics	1.5	
Metal	.3	
Glass, rubber, plastics	1.2	
Vehicles hand dismantled, bundled, sheared	6.0	4
Vehicles not processed	1.5	1

[1] Estimate.

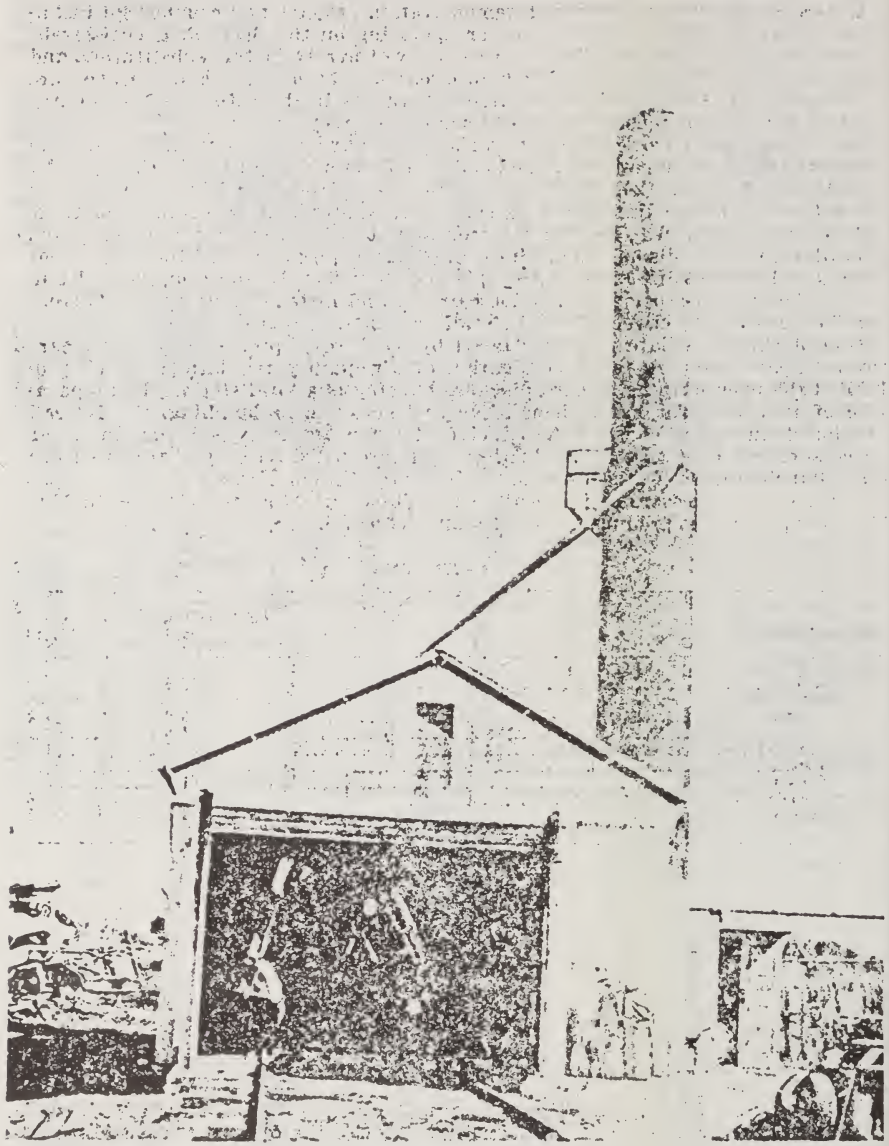


FIGURE 9.—Smokeless junk car incinerator showing two cars in position for burning.

The shredded material is then separated magnetically to reclaim the iron and steel, leaving a nonmagnetic fraction containing fabric, rubber, glass, plastics, and a mixture of nonferrous metals such as copper, aluminum, and zinc (figure 10). About 1.5 million tons of these nonmagnetic materials are generated each year, 300,000 tons of which are metals whose scrap value is at least $120 million. Although one company currently recovers part of these nonferrous metals mechanically, most of the potentially valuable nonmagnetic material is discarded. Our research has demonstrated a simple method for reclaiming a nonferrous metal concentrate from the nonmagnetic material by air classification and water separation. Today, there are about a half dozen commercial facilities in operation

or under construction which utilize this technology. We are now investigating techniques for further separation of this nonferrous metal concentrate into aluminum, zinc, and copper alloy fractions.

Because the makeup of cars is steadily changing, we foresee new and challenging separation problems when vehicles now in showrooms and on drawing boards for future production have served out their useful life and are ready to reenter the raw materials supply chain through recycling. We are now working on application of air- and water-separation techniques to recovery of plastics for reuse from new model cars. Several late-model cars have been furnished by the automobile industry so that we can identify their materials of construction for comparison with those of older cars now being scrapped, and can devise suitable, low-cost separation techniques. Substantial differences in the proportions of plastics, aluminum, magnesium, and low-alloy steels have already been identified (figure 11), and the information is being used by our researchers.

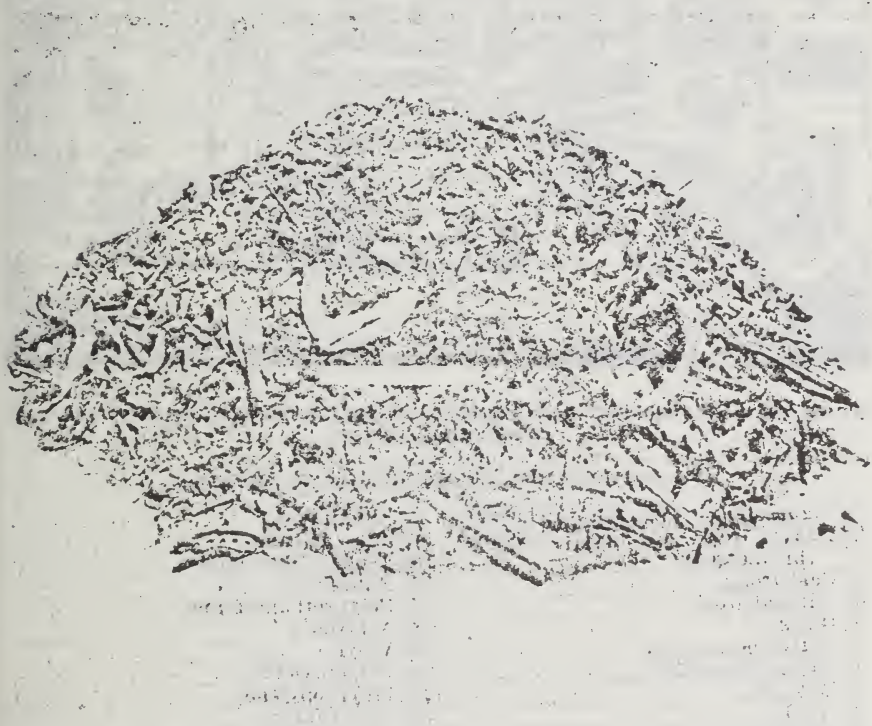


FIGURE 10.—Reject material from junk car shredding operations containing valuable nonferrous metals.

FIGURE 11.—Disassembled 1972 Mercury Montego automobile used for junk car composition studies.

COMPOSITION OF PARTS ON 1972 MERCURY MONTEGO

1. Light steel (<⅛-inch thickness)
2. Heavy iron and steel (>⅜-inch thicknesses)
3. Cast iron
4. Mineral wool
5. Glass
6. Activated carbon
7. Nylon (molded)
8. Bakelite
9. Lead
10. Stainless steel
11. Asbestos
12. Copper/brass
13. Aluminum
14. Zinc die cast
15. Asphalt-like plastic
16. Rubber
17. Polyurethane foam
18. Acrylic
19. Vinyl
20. Polyethylene
21. Polypropylene
22. Nylon fabric
23. ABS plastic
24. Paper
25. Cotton, jute, etc.

Because of their high visibility to the general public, urban refuse and junk autos have received nationwide attention, but there is another major category of waste that is harder to see, though nationally significant. This category, which includes wastes generated by industrial and manufacturing operations, demands attention because of the opportunity it represents to promote wise, efficient use of mineral resources through recycling. These wastes also sometimes pose major pollution problems that could be reduced by converting pollutants and wastes to useful materials. Table 5 shows typical industrial and manufacturing wastes, examples of the operations that generate them, and the valuable elements that should be recovered.

Parts of our research program have been aimed at recovering metals and minerals from these diverse wastes—smelter dusts, slags, chemical slurries, sludges, electroplating waste solutions, grinding swarfs, battery scrap, and industrial gases.

Substantial progress has been made in treating some of them. For example, in primary aluminum smelting operations, about 200 lbs of dross are produced for each ton of metal processed. This dross contains a significant quantity of metallic aluminum that must be recovered to maintain the efficiency of the overall smelting process. In current industrial practice, recovering the aluminum produces a high-salt slag that is difficult to dispose of because of the possibility of water pollution. And it still contains some finely-divided aluminum that should be recovered. In cooperation with firms that process dross, we are working to improve the efficiency of aluminum recovery and to avoid the risk of water pollution. We are also looking into the practicability of alternative procedures that would bypass the high-salt slag altogether.

TABLE 5.—TYPES OF INDUSTRIAL WASTES AND VALUABLE COMPONENTS

Waste	Source	Component
Slags and drosses	Smelting and refining	Lead, zinc, aluminum, copper, manganese, chromium, nickel, titanium.
Waste solutions	Electroplating, etching, and pickling.	Cadmium, nickel, copper, chromium, cobalt, gold, silver, molybdenum, mercury.
Metallurgical dusts	Smelting and fabrication	Iron, zinc, lead, copper, arsenic, antimony, bismuth, chromium, nickel, cobalt.
Sludges and grinding swarfs	Machining and manufacturing	Chromium, nickel, cobalt, iron, manganese, tungsten, zircon, diamonds.
Slimes and tailings	Leaching and ore treatment	Alumina, iron, copper, precious metals, phosphate, uranium.
Industrial gases	Pyrometallurgical operations	Sulfur, fluorine.

TABLE 6.—*Lead battery scrap*

Number scrapped	42,000,000.
Lead recovered	348,000 tons.
Antimony recovered	17,000 tons.
Current processing problem	SO_2 evolution.
New, nonpolluting process	Commercial adoption.

Water pollution—and the loss of valuable materials—affects many other industrial operations. For instance, waste solutions from electroplating operations are a problem in virtually every industrialized area of the country. If disposed of without treatment, they pollute the water and often release toxic constituents. They also carry valuable metals out of the recycling circuit. We solved part of the problem by the simple step of bringing together, in physical combination, waste solutions from different, adjacent operations. By combining acid waste and cyanide solutions, metal cyanide compounds are precipitated, the acid is neutralized, and water acceptable for reuse or discharge to streams is produced. The metals can then be recovered from the solid precipitate that is produced. We call this the waste-plus-waste technique, and it works.

Lead storage batteries are as ubiquitous as our automobiles. When the batteries are worn out, the lead in them is recovered for reuse. Table 6 shows how much lead and antimony (alloyed with the lead to make it stronger)is recovered. Current practice uses blast-furnace smelting of lead-battery scrap to produce secondary lead, but this operation also generates sulfur dioxide. To avoid the production of this pollutant the Bureau of Mines developed a technique to tie up the sulfur with lime as calcium sulfate, before smelting. One West Coast processor added the step to his operations almost as soon as we announced its development.

Sulfur dioxide in industrial stack gases cannot always be handled by a simple preliminary treatment of the material being processed or burned. To meet air pollution requirements, this sulfur dioxide must be removed from stack and flue gases. And in major operations like copper smelting and electric power generation, the sulfur in the gas waste represents a significant resource loss if it is not recovered in a reusable form. The most prominent method now receiving attention for desulfurizing these gases is limestone scrubbing, which produces enormous quantities of waste calcium sulfate sludge, and does not recover the sulfur for use. We feel that the Citrate Process developed by the Bureau of Mines offers a better alternative for gas cleaning because it recovers elemental sulfur, an easily used material.

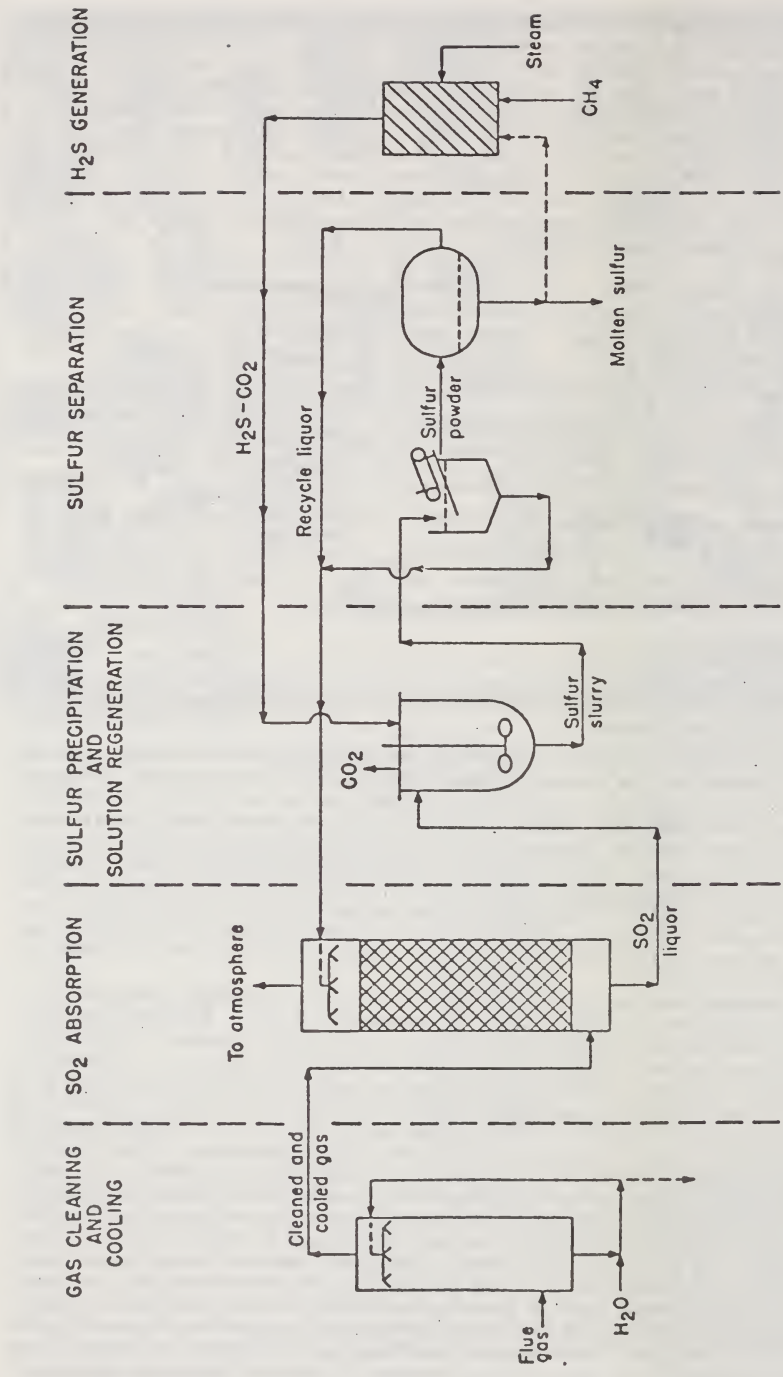
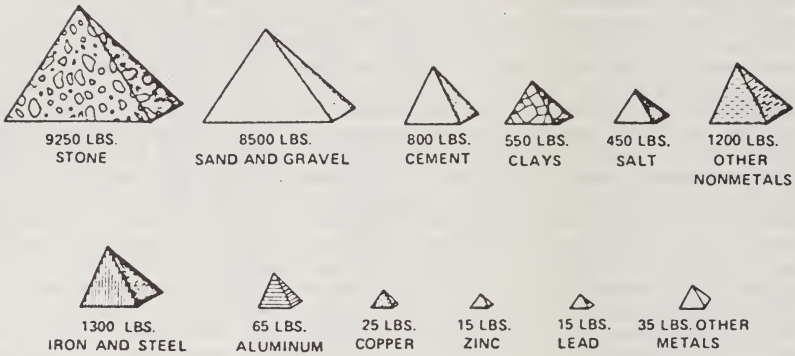


FIGURE 12.—Generalized citrate process flowsheet.

Figure 12 shows the essential steps of this process. After sulfur dioxide is scrubbed from the gas stream by the citrate solution, it is reacted with hydrogen sulfide to produce sulfur and release the citrate solution for reuse. The process was originally developed to clean up smelter smoke. Now we are moving ahead with a major pilot plant to apply the Citrate Process to powerplant flue gas. For a typical powerplant burning 3-percent sulfur coal, we estimate that the citrate scrubbing step will add about 2 mills to the cost of a kilowatt-hour of-electricity.

The progress in solid waste management to date, and the rate which new technology is being accepted and utilized, clearly indicate that our Nation is headed in the right direction. Therefore, we believe that the technologic approach should be continued. Many unsolved waste problems still require technical solutions, and much of the technology currently being developed will require large-scale demonstration as part of the technology transfer process. H.R. 406 and H.R. 5487, however, would divert our country's attention from this urgently needed effort and channel national efforts instead into an extensive regulatory program. Rules and regulations, we believe, are best decided as local issues, and waste management laws, in our views, should be left in the hands of State, County and local governments. The most effective Federal role in solid wastes is one of technical assistance and research and development. With regard to H.R. 406, we agree that the legislation could help reduce the amount of metal and glass being discarded. However, the effect of banning nonreturnable containers would be minimal in terms of our overall solid waste burden in that many other items besides beverage containers are disposed of in solid wastes. In addition, it could result in other adverse consequences, not all of which are entirely clear. Furthermore, enactment of H.R. 406 might lull citizens into a mistaken belief that the country's solid waste management needs have all been taken care of. With respect to H.R. 5487, we believe existing authorities are adequate to meet existing needs and to carry out an appropriate Federal program. In any event, consideration of an expanded program such as this measure contemplates should be deferred in view of the economic and budgetary considerations outlined by the President in recent months.

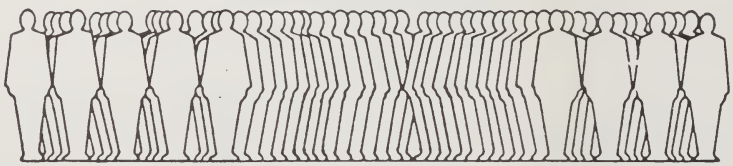
ABOUT 40,000 POUNDS OF NEW MINERAL MATERIALS ARE REQUIRED ANNUALLY FOR EACH U.S. CITIZEN



PLUS

TO GENERATE:

ENERGY EQUIVALENT TO 300 PERSONS WORKING AROUND-THE-CLOCK FOR EACH U S. CITIZEN

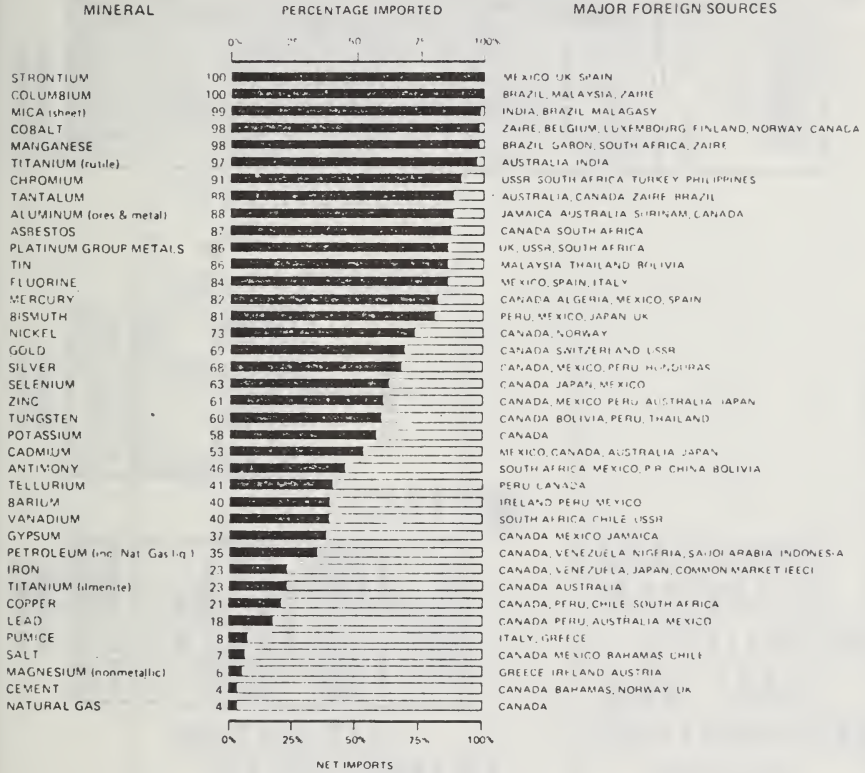


U. S. TOTAL USE OF NEW MINERAL SUPPLIES IN 1974 EXCEEDED

4 BILLION TONS !

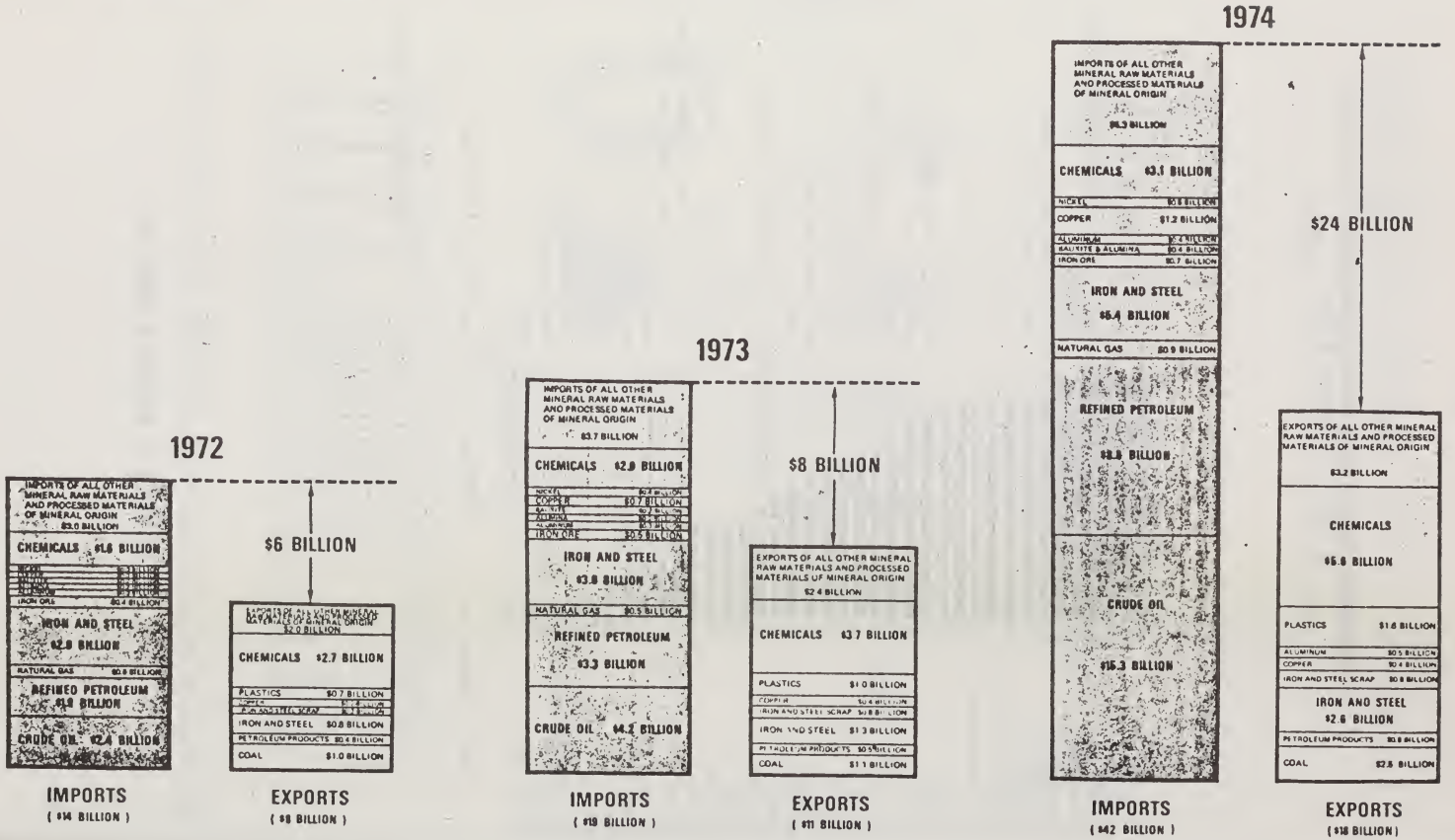
U. S. BUREAU OF MINES

IMPORTS SUPPLIED SIGNIFICANT PERCENTAGE OF TOTAL U.S. DEMAND IN 1974


MINERAL
PERCENTAGE IMPORTED
MAJOR FOREIGN SOURCES
0%
25%
50%
75%
100%
STRONTIUM 100 MEXICO, UK, SPAIN
COLUMBIUM 100 BRAZIL, MALAYSIA, ZAIRE
MICA (sheet) 99 INDIA, BRAZIL, MALAGASY
COBALT 98 ZAIRE, BELGIUM, LUXEMBOURG, FINLAND, NORWAY, CANADA
MANGANESE 98 BRAZIL, GABON, SOUTH AFRICA, ZAIRE
TITANIUM (rutile) 97 AUSTRALIA, INDIA
CHROMIUM 91 USSR, SOUTH AFRICA, TURKEY, PHILIPPINES
TANTALUM 88 AUSTRALIA, CANADA, ZAIRE, BRAZIL
ALUMINUM (ores & metal) 88 JAMAICA, AUSTRALIA, SURINAM, CANADA
ASBESTOS 87 CANADA, SOUTH AFRICA
PLATINUM GROUP METALS 86 UK, USSR, SOUTH AFRICA
TIN 86 MALAYSIA, THAILAND, BOLIVIA
FLUORINE 84 MEXICO, SPAIN, ITALY
MERCURY 82 CANADA, ALGERIA, MEXICO, SPAIN
BISMUTH 81 PERU, MEXICO, JAPAN, UK
NICKEL 73 CANADA, NORWAY
GOLD 69 CANADA, SWITZERLAND, USSR
SILVER 66 CANADA, MEXICO, PERU, HONDURAS
SELENIUM 63 CANADA, JAPAN, MEXICO
ZINC 61 CANADA, MEXICO, PERU, AUSTRALIA, JAPAN
TUNGSTEN 60 CANADA, BOLIVIA, PERU, THAILAND
POTASSIUM 58 CANADA
CADMIUM 53 MEXICO, CANADA, AUSTRALIA, JAPAN
ANTIMONY 46 SOUTH AFRICA, MEXICO, P.R. CHINA, BOLIVIA
TELLURIUM 41 PERU, CANADA
BARIUM 40 IRELAND, PERU, MEXICO
VANADIUM 40 SOUTH AFRICA, CHILE, USSR
GYPSUM 37 CANADA, MEXICO, JAMAICA
PETROLEUM (inc. Nat. Gas liq.) 35 CANADA, VENEZUELA, NIGERIA, SAUDI ARABIA, INDONESIA
IRON 23 CANADA, VENEZUELA, JAPAN, COMMON MARKET (EEC)
TITANIUM (ilmenite) 23 CANADA, AUSTRALIA
COPPER 21 CANADA, PERU, CHILE, SOUTH AFRICA
LEAD 18 CANADA, PERU, AUSTRALIA, MEXICO
PUMICE 8 ITALY, GREECE
SALT 7 CANADA, MEXICO, BAHAMAS, CHILE
MAGNESIUM (nonmetallic) 6 GREECE, IRELAND, AUSTRIA
CEMENT 4 CANADA, BAHAMAS, NORWAY, UK
NATURAL GAS 4 CANADA
0%
25%
50%
75%
100%
NET IMPORTS

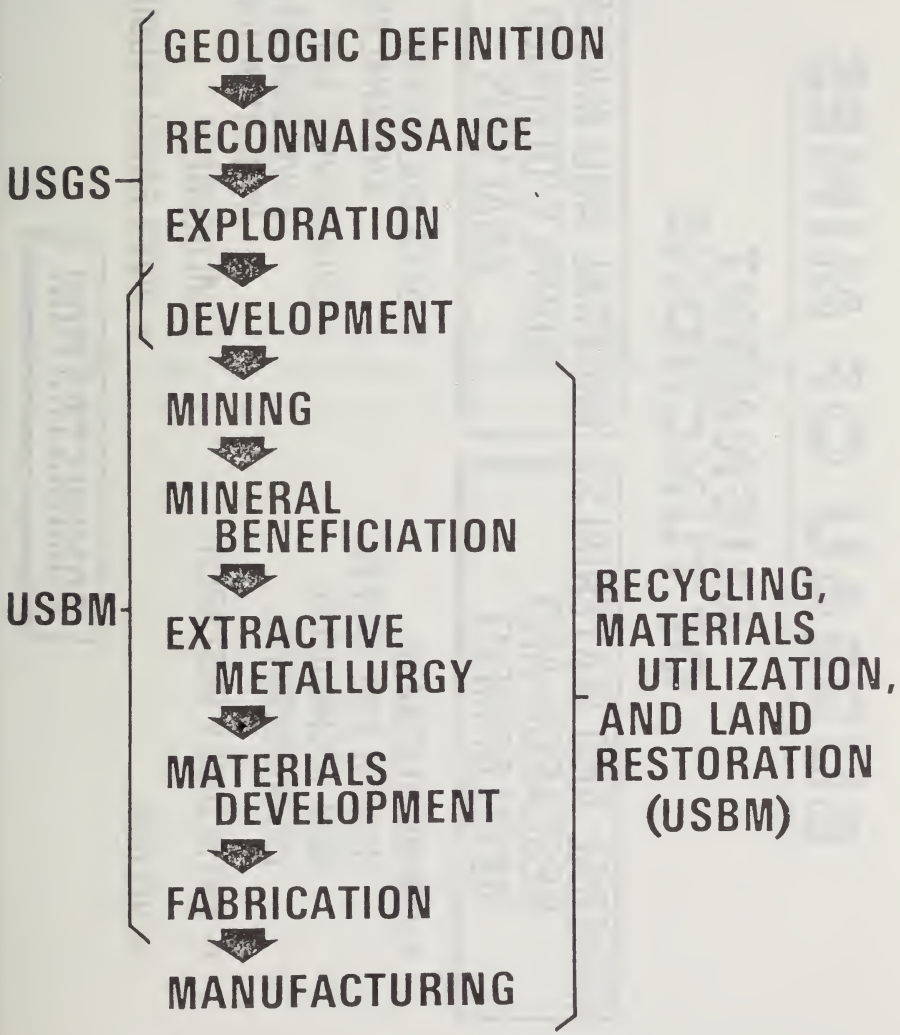
U.S. BUREAU OF MINES (import-export data from U.S. Bureau of the Census)

U.S. IMPORTS AND EXPORTS OF RAW AND PROCESSED MINERALS


1972
IMPORTS OF ALL OTHER MINERAL RAW MATERIALS AND PROCESSED MATERIALS OF MINERAL ORIGIN $3.0 BILLION
CHEMICALS $1.6 BILLION
IRON ORE $0.4 BILLION
IRON AND STEEL $2.9 BILLION
NATURAL GAS $0.8 BILLION
REFINED PETROLEUM $1.9 BILLION
CRUDE OIL $2.4 BILLION
IMPORTS ($14 BILLION)
$6 BILLION
EXPORTS OF ALL OTHER MINERAL RAW MATERIALS OF MINERAL ORIGIN $2.0 BILLION
CHEMICALS $2.7 BILLION
PLASTICS $0.7 BILLION
IRON AND STEEL $0.8 BILLION
PETROLEUM PRODUCTS $0.4 BILLION
COAL $1.0 BILLION
EXPORTS ($8 BILLION)
1973
IMPORTS OF ALL OTHER MINERAL RAW MATERIALS AND PROCESSED MATERIALS OF MINERAL ORIGIN $3.7 BILLION
CHEMICALS $2.9 BILLION
COPPER $0.7 BILLION
IRON ORE $0.5 BILLION
IRON AND STEEL $3.8 BILLION
NATURAL GAS $0.5 BILLION
REFINED PETROLEUM $3.3 BILLION
CRUDE OIL $4.2 BILLION
IMPORTS ($19 BILLION)
$8 BILLION
EXPORTS OF ALL OTHER MINERAL RAW MATERIALS AND PROCESSED MATERIALS OF MINERAL ORIGIN $2.4 BILLION
CHEMICALS $3.7 BILLION
PLASTICS $1.0 BILLION
IRON AND STEEL $1.3 BILLION
PETROLEUM PRODUCTS $0.5 BILLION
COAL $1.1 BILLION
EXPORTS ($11 BILLION)
1974
IMPORTS OF ALL OTHER MINERAL RAW MATERIALS AND PROCESSED MATERIALS OF MINERAL ORIGIN $6.3 BILLION
CHEMICALS $3.1 BILLION
NICKEL $0.6 BILLION
COPPER $1.2 BILLION
ALUMINUM $0.4 BILLION
BAUXITE & ALUMINA $0.4 BILLION
IRON ORE $0.7 BILLION
IRON AND STEEL $5.4 BILLION
NATURAL GAS $0.9 BILLION
REFINED PETROLEUM $8.8 BILLION
CRUDE OIL $15.3 BILLION
IMPORTS ($42 BILLION)
$24 BILLION
EXPORTS OF ALL OTHER MINERAL RAW MATERIALS AND PROCESSED MATERIALS OF MINERAL ORIGIN $3.2 BILLION
CHEMICALS $5.0 BILLION
PLASTICS $1.6 BILLION
ALUMINUM $0.5 BILLION
COPPER $0.4 BILLION
IRON AND STEEL SCRAP $0.8 BILLION
IRON AND STEEL $2.6 BILLION
PETROLEUM PRODUCTS $0.8 BILLION
COAL $2.5 BILLION
EXPORTS ($18 BILLION)

U.S. BUREAU OF MINES (DATA FROM U.S. BUREAU OF THE CENSUS)

THE MINERAL CYCLE



BUREAU OF MINES

ALIGNMENT OF FUNCTIONS

MINERAL AND MATERIALS RESEARCH AND DEVELOPMENT

- MINING RESEARCH
  - HEALTH AND SAFETY
  - NEW TECHNOLOGY
  - ENVIRONMENTAL
- METALLURGY RESEARCH
- HELIUM

MINERAL AND MATERIALS SUPPLY/DEMAND ANALYSIS

- DATA COLLECTION AND ANALYSIS
- ENGINEERING AND ENVIRONMENTAL INVESTIGATIONS
- WILDERNESS
- RIVER BASIN STUDIES

ADMINISTRATION

IV. RESOURCE RECOVERY: POTENTIAL AND PROBLEMS

(Excerpted from: U.S. Environmental Protection Agency, Third Report to Congress: Resource Recovery and Waste Reduction. Washington: U.S. Government Printing Office, 1975.)

Chapter 3

ENERGY RECOVERY FROM POST-CONSUMER SOLID WASTE

The *Second Report to Congress* documented a turning point in resource recovery. When that report was prepared, techniques for recovering energy and materials from the waste stream were just beginning to be demonstrated on a large scale; and only a few communities were preparing to build systems.

The interval since then has witnessed the construction of three demonstration facilities (including EPA's energy recovery demonstration in Baltimore); the completion of the Nashville, Tennessee, district heating and cooling system; the start of construction of five full-scale, locally funded recovery systems; and the continued development and evaluation of EPA's demonstrations in Franklin, Ohio, and St. Louis, Missouri.

Today, as development of new technologies continues, the implementation of a resource recovery system has become for many communities a serious concern and a major activity. This *Third Report to Congress* presents a summary of resource recovery in the context of the progress that has been made over the past year.

This chapter presents estimates of the amount of energy potentially recoverable from solid waste, a description of the technology and of the markets for the recovered energy, and an evaluation of the availability of technology for energy recovery.

QUANTITY OF ENERGY POTENTIALLY RECOVERABLE

Theoretical Potential

In 1973, approximately 135 million tons per year of residential and commercial solid waste were generated. About 70 to 80 percent of this waste was combustible, having an average energy content of about 9 million British Thermal Units (Btu) per ton. Theoretically, if all solid waste in the U.S. had been converted into energy in 1973, about 1.2 quadrillion Btu per year would have been generated. This is equal to more than 564,000 barrels per day of oil equivalent (B/DOE) or 206 million barrels per year of oil equivalent (B/YOE). Growth in population and per capita waste generation would cause these figures to increase to 1,440 trillion Btu per year by 1980, or about 680,000 B/DOE or 248 million B/YOE. These and other findings are summarized in Table 22.

Available Potential

Not all waste is available for energy recovery. Energy recovery systems require large quantities of waste (at least 200 to 250 tons per day) delivered for processing at one site in order to achieve economies of scale. For this reason, energy recovery appears feasible only in more densely populated areas, such as most Standard Metropolitan Statistical Areas (SMSA's). If energy recovery had been practiced in all SMSA's in 1973, almost 900 trillion Btu would have been recovered. This is equal to more than 424,000 B/DOE, or 154 million B/YOE. By 1980, the energy potentially recoverable from the SMSA waste stream is projected to be about 1,085 trillion Btu per year, the equivalent of more than 512,000 B/DOE, or 187 million B/YOE.

Impact on Energy Demand

The quantity of energy potentially available from the waste stream of more densely populated areas (SMSA's) is significant. For example, the 424,000 barrels per day of oil equivalent that was available in SMSA's in 1973 is equal to:

4.6 percent of fuel consumed by all utilities in 1973 (9.2 million B/DOE)

Table 22

ENERGY POTENTIALLY RECOVERABLE FROM RESIDENTIAL AND COMMERCIAL SOLID WASTE*

	1973			1980		
	Btu† (trillion)	B/DOE‡ (thousand)	B/YOE§ (million)	Btu (trillion)	B/DOE (thousand)	B/YOE (million)
Theoretical	1,194	564	206	1,440	680	248
Available¶	899	424	154	1,085	512	187
Projected recovery	–	–	–	85	40	15

*These estimates are a function of (1) population; (2) the average amount of residential and commercial solid waste generated per person, and (3) the energy content of the waste (4,500 Btu per pound). The heating value of 4,500 Btu per pound (9 million Btu per ton) is generally accepted for "as received," unprocessed waste as delivered by a collection truck to a processing or disposal facility.

†Btu: British thermal unit.

‡B/DOE: Barrels per day of oil equivalent. (Assuming 5.8 million Btu per barrel of oil and 365 days per year.)

§B/YOE: Barrels per year of oil equivalent.

¶Based on all Standard Metropolitan Statistical Areas (SMSA's).

NOTE: Different waste processing methods have different recovery efficiencies. For example, a shredding/air classification waste processing system loses some potential energy by removing heavy combustibles from the fuel fraction, while high-temperature incineration with no prior classification would lose far less potential energy. However, no adjustment was made to allow for such processing losses or energy conversion efficiencies (of, say, steam or electricity) because no prejudgment can be made as to which energy recovery method would be used in any given situation.

10 percent of all the coal consumed by utilities in 1973 (4.1 million B/DOE)

28 percent of the oil projected to be delivered through the Alaskan pipeline (1.5 million B/DOE)

1 percent of all energy consumed in the United States in 1973 (35.6 million B/DOE)

The energy recoverable from SMSA's can light every home and office building in the country and is equivalent to twice the gasoline savings estimated for the 55-miles-per-hour fuel conservation program in 1973-74.

Perhaps more significant is the impact on energy needs of individual users. For example, many industrial plants can generate at least half the process steam they use from solid waste fuel, thus reducing dependence on fossil fuels.

Projected Implementations of Energy Recovery Systems

Based on energy recovery systems existing or planned at the present time, it is projected that by 1980 almost 30 cities and counties around the country should be operating the equivalent of about thirty-six 1,000-ton-per-day plants, recovering an estimated 85 trillion Btu per year, or 40,000 B/DOE, or 15 million B/YOE.

Effect of Paper Recycling on Energy Recovery

Wastepaper can be recycled as a fiber source, or it can be converted to energy. From a national perspective, recycling of wastepaper could reduce the amount of energy potentially recoverable from the waste stream by 5 to 10 percent or more, depending on the quantity and type of paper recycled. However, EPA studies show that existing paper recycling levels could be increased significantly without seriously affecting the fuel characteristics of the remaining solid waste.

Because these options—recycling or energy recovery—are mutually exclusive with respect to wastepaper at the time of disposal (although recycled paper can be converted to energy later), there can be a problem at the local level for those making decisions about resource recovery systems. The effect of recycling paper on the fuel value of solid waste varies with the level of recycling rates. If newspaper recycling efforts were increased to their maximum practical levels, the as-fired heating value, burn-out level, and sulfur content of the fuel would change by

not more than 6 percent. If total paper recycling levels were doubled, the burn-out and sulfur content would change by less than 3 percent; the as-fired heating value would decrease by 9 percent; and the ash content would increase by 14 percent. Although paper recycling rates are far below their maximum practical levels at the present time, if such levels were approached, the effect on solid waste fuel characteristics would become more pronounced. Therefore, the design of energy recovery plants should take into account the effects of potential paper recycling levels.

TECHNOLOGY AND MARKETS

Many different approaches to recovering the energy value of solid waste are presently being examined. Waterwall incinerators are being used to generate steam in a number of U.S. cities. A new waterwall incinerator was constructed in Nashville, Tennessee, in mid-1974. A contract was signed in 1974 for the sale of steam produced at the Braintree, Massachusetts, incinerator. A waterwall incinerator to generate steam for industrial processing is under construction at Saugus, Massachusetts. In Baltimore, with financial support from an EPA solid waste demonstration grant, a pyrolysis system that will generate steam is beginning operation. EPA's St. Louis project is currently demonstrating a system that uses the shredded, combustible portion of solid waste as a coal substitute in a utility boiler. Chicago, Ames, Iowa, and Bridgeport, Connecticut, are building similar systems. Several other communities are considering similar systems and extension of the concept to oil-fired boilers, as well as use of wet-pulped or pelletized solid waste as a fuel.

Pyrolysis systems are being developed to convert solid waste into liquid and gaseous fuels. Two of these systems are the Garrett Research and Development Company's system for producing an oil-like fuel, which is being demonstrated with grant support from EPA in San Diego County, California, and Union Carbide's system for producing a gaseous fuel, which is being tested by that company at its plant in South Charleston, West Virginia. The recovery of methane from landfilled solid waste is being practiced at a pilot plant in Los Angeles and will be demonstrated at Mountain View, California, with grant support from EPA. Electrical power generation using a gas turbine is being explored in a research project conducted by the Combustion Power Company with EPA support.

These technologies enable solid waste to be converted into a number of different energy forms, including gaseous, liquid, and solid fuels as well as steam and electricity. The energy recovery system that should be employed in any particular community depends upon the market for the product.[1]

The market value of a solid waste energy product should be equivalent, on the basis of heat produced, to the value of the fuel which it replaces, less any additional costs incurred in its use. The current energy crunch has significantly increased the value of these products and has reduced the need to provide special incentives to enhance their marketability.

To be marketable, however, the solid waste energy products must have qualities acceptable to the user. Steam and electricity produced from solid waste are equivalent to those products from other sources, but fuels produced from solid wastes are physically and chemically different from their fossil fuel counterparts. Characteristics such as ash content, heat value, corrosiveness, viscosity, and moisture content have to be acceptable to the user. For all energy products derived from solid waste, such factors as reliability, quantity, and availability are also important.

The following is a review of the characteristics of the major energy products recoverable from solid waste, the status of technology for recovery, and the potential markets.

Solid, Liquid, and Gaseous Fuels

Solid, liquid, and gaseous fuels can be produced from solid waste by a number of systems currently under development. These fuels can be used as a supplement to their fossil fuel counterparts: coal, petroleum, and natural gas.

Mixed municipal solid waste has a heating value of approximately 4,500 Btu per pound. The heating value of solid waste is compared to that of fossil fuels in Table 23.

Systems for Producing Fuels. The technology for converting solid waste into fuel is very new but developing rapidly. All of the systems under consideration today were conceived of since 1968.

Prepared Solid Waste as a Supplemental Fuel. The city of St. Louis, with demonstration grant assistance from EPA, is producing a dry, shredded solid waste

pressurized fluid bed combustor. The hot, high-pressure gases from the combustor pass through several stages of air-cleaning equipment (separators) to remove particulates. The cleaned gases are passed through a gas turbine that drives a 1,000-kilowatt generator. The pilot plant operates at only 45 pounds per square inch gauge (psig); commercial plants would operate at pressures in excess of 100 psig.

Performance problems have caused accelerated deterioration of the turbine blades and thus have slowed the development of this process. The deterioration and other problems must be solved before this approach becomes a technically and economically feasible system for energy recovery.

Another electrical generation concept, the burning of solid waste to generate steam to drive an electric turbine, has been proposed in several communities, including Hempstead, New York; and Dade County, Florida.

Potential Market. The major concern in marketing electricity is that it can be marketed only to the electric utility serving the area because, within that service area, the utility is generally exempt from competition. The only exception to that situation would be a municipally owned utility, but only a small fraction of the nation's electric generating capacity falls in this category.

The price that a utility will pay for electricity will depend upon whether it is used to satisfy base-load or peak-load demands. Peak-load electricity commands a much higher price than base-load, but it requires a much higher capital investment in equipment. A municipality would need to sell electricity on a continuous basis (i.e., as base-load) in order to maintain a continuous solid waste disposal operation at the lowest possible capital cost.

A municipality considering the sale of electricity to a utility could seek to establish a floating price for the electricity whereby the price would rise as the demand on the utility increased. The price would be a function of the incremental direct costs the utility would incur in producing the additional electricity.

Comparison of Energy Forms

The key to marketing energy from solid waste is producing a form of energy that can be sold and used without significant inconvenience to the user. In addition, the energy should be storable and transportable so that the solid waste facility can be built and operated independently of the energy market.

Steam and electricity satisfy the first objective but neither can be stored, and steam can be transported only very short distances.

The waste-derived solid and liquid fuels can be transported and can even be stored for brief periods of time (several days to several weeks). However, both fuels require the user to install special storing and firing facilities. In addition, the user must follow special handling procedures to minimize problems of air pollution and corrosion.

Waste-derived gaseous fuels are less likely to require special handling or need separate facilities for storage and firing, but those currently being produced cannot economically be compressed for extended storage and shipment. The best of the gaseous fuels cannot be shipped more than 2 miles.

EVALUATION OF AVAILABILITY OF TECHNOLOGY

Solid waste disposal systems must operate reliably and with a minimum of technical risk. Furthermore, the system must operate without degrading the environment and at a reasonable cost. Risk and reliability are usually evaluated through examination of existing, full-size systems in actual operation.

Although no energy recovery system is presently risk-free, two methods are commonly considered "commercially available." Other, possibly better, technologies are being developed and are projected to become commercially available throughout the 1977 to 1982 period.

Technologies Now Available

The technology that is now commercially available includes (1) the generation of steam (for district heating and cooling or for industrial processing) in a waterwall incinerator fueled solely by unprocessed solid waste and (2) the use of prepared (shredded and classified) solid waste as a supplement to pulverized coal in electric utility boilers. As noted earlier, there are already many waterwall incinerators in the United States. The use of prepared solid waste as a supplementary boiler fuel is being demonstrated in St. Louis and similar systems are being implemented by communities across the country, including: Chicago; Bridgeport, Connecticut; Ames, Iowa; Wilmington, Delaware (with EPA solid waste demonstration

grant support): Monroe County, New York (Rochester area); and Milwaukee, Wisconsin.

These technologies are defined as commercially available because they have been demonstrated in large-scale facilities and because private industry is offering the systems for sale. While there is little risk of technical failure for waterwall incinerators, their long-term reliability has not been established. Solid waste has been used as a supplement to coal or oil in steam or steam-electric boilers in Europe for about 20 years. However, the practice is relatively new in the United States because most of our steam-electric boilers, unlike European boilers, fire fuels in suspension, and therefore the solid waste must be processed before it is fired as a supplementary fuel into the boiler. The St. Louis project has provided the only experience with this technology thus far. Until more systems are actually built and operated, there will continue to be some risk associated with their implementation. (See Chapter 6 for a discussion of the constraints to implementation of resource recovery systems.)

Technologies in Development

Other, possibly superior, technologies are being developed. Pyrolysis, which converts solid waste into gaseous or liquid fuels, is being demonstrated with EPA solid waste demonstration grant support in Baltimore and San Diego County, and without Federal support in South Charleston, West Virginia. These systems are expected to become fully operational during the 1977 to 1980 period.

In addition, the production of methane gas through controlled biological decomposition (anaerobic digestion) of solid waste is about to be performed at pilot-plant scale. Commercial implementation of this technology is projected to begin in the 1980 to 1982 period.

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RECYCLED MATERIALS MARKETS: FEBRUARY 1975 - A SUMMARY

by Stephen A. Lingle*

This paper provides a brief review of the market demand for materials recovered from municipal solid waste. More comprehensive discussions may be found in various EPA publications including both the First and Second Reports to Congress on Resource Recovery and Source Reduction. This paper briefly reviews market conditions during the 1973-1974 period and describes factors underlying longer term trends in recycled materials markets.

The Market Situation in January 1975

Recycled materials markets in the 1973-1974 period experienced both the highest and lowest prices of several decades. Late 1973 and early 1974 was a period of rapidly increased demand for recycled materials and record high prices. However, in late 1974, prices of many recycled materials declined significantly, due to reduction in both domestic and export demand. By January 1975, scrap steel, copper and aluminum prices had dropped by approximately 50 percent, 60 percent, and 30 percent respectively from their 1974 highs. Wastepaper prices were one-third to one-fourth the levels of only a few months before. Many businesses, cities, and charitable organizations were unable to sell some scrap materials at all, particularly paper.

Causes of the Market Turnaround

The wastepaper market provides a good example of the nature of markets for recycled materials and dramatically illustrates the market turnarounds in 1973 and 1974.

The period January 1973 to March 1974 was a time of unprecedented high demand for manufactured goods. This was essentially a material shortage period. Almost all paper mills were operating at full capacity. Virgin pulp capacity could not be expanded in the short term as this requires substantial capital investment and construction. Therefore, many paper mills that generally would use little or no wastepaper were

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bidding for wastepaper supplies. In addition, export demand for wastepaper increased significantly during this period. The combination of these two factors led to a sharp rise in wastepaper demand and prices.

By March 1974, four factors began operating that together brought about a sharp curtailment in wastepaper consumption and decrease in wastepaper prices.

1. Paper and paperboard consumption began leveling off, allowing virgin pulping capacity to "catch-up". As a result, many virgin-oriented mills dropped out of the wastepaper market.

2. Production levels in the paper industry declined due to the general economic recession in the nation. This was especially significant in the construction paper sector due to the decline in the housing industry.

3. Wastepaper exports declined.

4. Inventories of wastepaper supplies had increased due to the "demand pull" of previous months.

These factors in combination eventually resulted in the depressed market conditions of late 1974-early 1975. The market situation will probably improve in 1975, and prices and consumption will probably settle out at pre-1973 levels by the end of the year. This increase and decrease in prices and consumption is typical in the wastepaper industry. Wastepaper is the last fiber to be used in times of shortage and the first to be discontinued during cut-backs.

What is the Longer Term Trend?

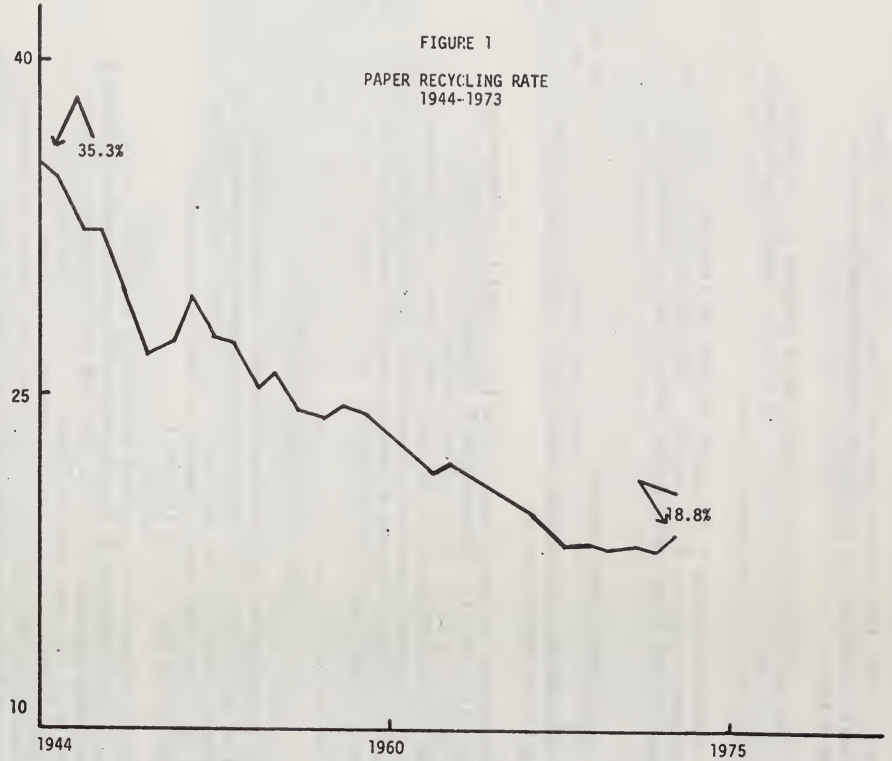
Significantly, the recycling rate (domestic recycled material consumption as a fraction of overall domestic material consumption) for many secondary materials has declined for many years. The recycling rate for paper declined from 35 percent in 1944 to approximately 19 percent at the end of 1974 (Figure 1).

The wide fluctuations that have occurred in wastepaper markets since 1950 are illustrated by the wholesale price index shown in Figure 2. Prices of other secondary materials show similar instability. Scrap steel prices in 1974 are shown in Figure 3. It was the fluctuating market demand, similar to that which occurred in 1973 and 1974, that caused these price fluctuations. Since prices for virgin raw materials have shown no similar fluctuations, this suggests that secondary materials are used, to a significant degree, as commodities of last resort--phased in or out with changes in capacity utilization and total production.

This is particularly true of materials recycled from post-consumer waste. The scrap generated in manufacturing and converting plants is recycled at a relatively consistent rate due to its purity and proximate point of generation. Demand fluctuations thus impact most significantly on efforts to recover materials from post-consumer solid waste.

FIGURE 1

PAPER RECYCLING RATE
1944-1973

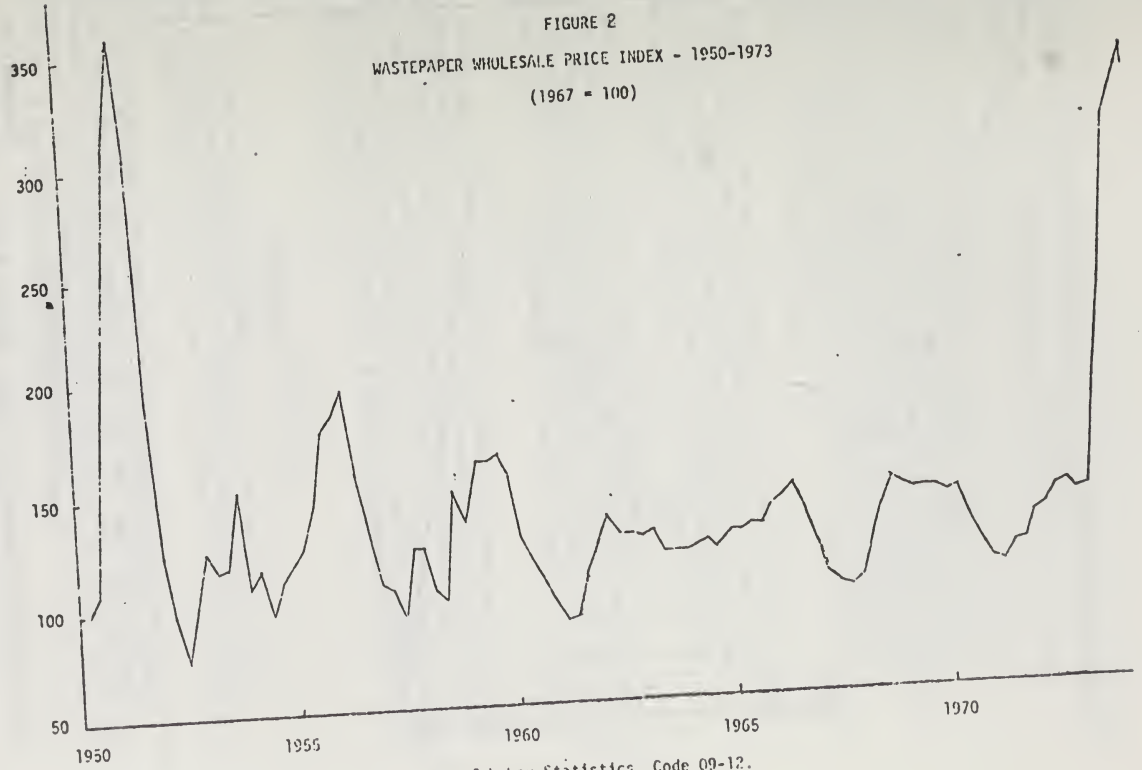


SOURCE: (1944-1969 Data) Darnay, A., and Franklin, W.E. Salvage markets for materials in Solid Waste. U.S. Environmental Protection Agency, 1972, p. 45-18; (1970-1972 Data). EPA calculations based on American Paper Institute, Statistics of Paper and Paperboard - 1973, p. 43, 61; (1972 Data) EPA estimate based on preliminary U.S. Dept. of Commerce data (1973).

FIGURE 2

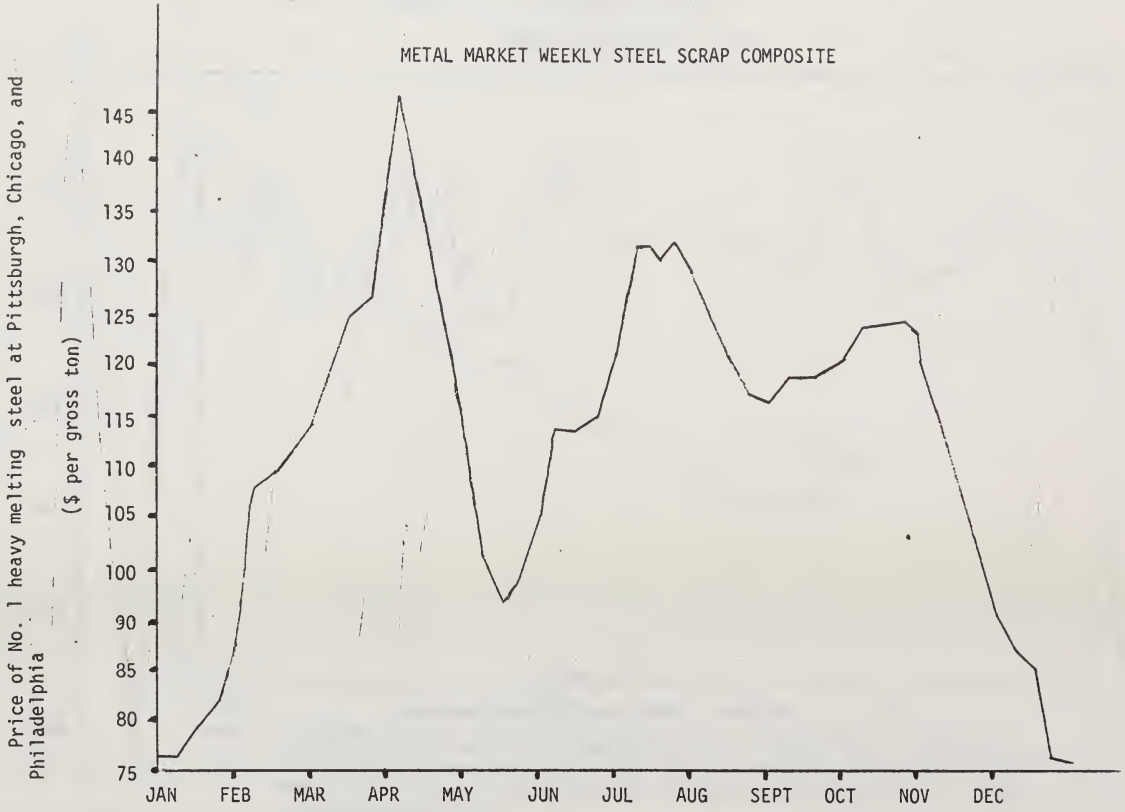
WASTEPAPER WHOLESALE PRICE INDEX - 1950-1973

(1967 = 100)



SOURCE: U.S. Bureau of Labor Statistics, Code 09-12.

FIGURE 3


METAL MARKET WEEKLY STEEL SCRAP COMPOSITE
Price of No. 1 heavy melting steel at Pittsburgh, Chicago, and Philadelphia
($ per gross ton)
145
140
135
130
125
120
115
110
105
100
90
85
80
75
JAN
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MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC

What Causes Fluctuations and Long-Term Declines in Waste Materials Markets?

The paper industry again provides an example of the basic factors influencing waste materials markets.

There is a historical orientation in the paper industry (and in other industries) to the use of virgin resources. While this can be attributed to a variety of factors, the vertical integration of the industry into timber production (or mining for metal consuming industries) is a key one. This has given the raw material user industries the ability to control a stable and predictable raw material supply while profiting from the use of that material. In addition, tax benefits provided as capital gain allowances (or depletion allowances for minerals) subsidize the use of virgin materials.

These factors combine to create a user market which favors virgin materials rather than recycled materials. EPA presently has underway a study of the economics of wastepaper versus virgin fiber use in the paper industry. Table 1 shows estimates of total process cost and return on investment for "virgin" and "recycled" paper mills.

These data show that in a predominant number of cases, the return on investment of mills using virgin resources is greater than that of recycled fiber mills. Even in cases where the return is nearly equivalent, it is likely that the virgin mill will continue to predominate due to vertical integration, industry experience, and more stable raw material prices.

While these economic comparisons are generalizations which cannot be representative of each specific mill situation, the data are generally consistent with an industry situation which finds marginal units of waste material use above the 20 percent level to be economically unattractive. The fact that there are not large differences in economic attractiveness in many cases suggests that for many products the economic balance could be relatively easily shifted.

Prognosis for the Future

The weak and erratic performance of recycled materials markets is not likely to improve unless existing mills permanently increase their use of waste materials or new mills designed to use waste materials are constructed.

It is difficult to foresee any normal market forces at present which will cause this to happen to a significant degree. Possible decreased availability (and increased price) of virgin materials in the future would move the markets in this direction, but the time frame or severity of such conditions is unknown at present.

TABLE 1

COMPARATIVE ECONOMICS OF PRODUCING PRODUCTS
FROM VIRGIN AND SECONDARY FIBER

($ per Metric Ton)

Product	% of Industry Output	Total Delivered Cost	Return on Fixed Capital
LINERBOARD	20		
100% Virgin		137	17.9
100% Secondary		169	8.7
80% Virgin; 20% Secondary		140	17.6
CORRUGATED MEDIUM	9		
85% Virgin; 15% Secondary		146	13.7
100% Secondary		157	11.8
53% Virgin, 48% Secondary		148	12.7
NEWSPRINT	6[1]		
100% Virgin		204	6.2
100% Secondary		194	10.6
67% Virgin; 33% Secondary		200	7.4
BOXBOARD	15		
100% Virgin		249	11.3[2]
100% Secondary		203	9.3[2]
TISSUE	6		
100% Virgin		257	*
100% Secondary		393	*
67% Virgin; 33% Secondary		288	*
PRINTING PAPER	22		
(Bond Type)			
100% Virgin		315	22.5
100% Secondary		422	4.2
67% Virgin; 22% Secondary		343	20.5
(Book Type)			
100% Virgin		323	21.8
100% Secondary		439	1.6
50% Virgin; 50% Secondary		367	19.0
(Groundwood Type)			
100% Virgin		269	6.3
100% Secondary		324	Negative
67% Virgin; 33% Secondary		269	6.3

[1]Approximately 70 percent of the newsprint consumed in the U.S. is imported.

[2]There is a large differential in selling price due to strength and weight characteristics.

*Data not available.

Increasing costs of waste collection and disposal to cities also suggest a greater attractiveness of resource recovery. Unfortunately, these costs (or cost savings due to resource recovery) are not fully realized by the industries that must use these materials, and these costs are largely not factored into the economics of industry recycling.

Significant changes in waste materials markets appear unlikely at this time in the absence of external forces.

Federal measures which might be appropriate to stimulate waste material use (such as tax credits to industry for use of recycled materials or charges to industry for use of virgin materials) are currently being investigated by EPA.

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MATERIALS

The dollars mount up for resource recovery

The technology may be an answer to communities' waste-disposal problems

On Aug. 13, Garrett Research & Development Corp. will break ground for a $10-million facility to remove recyclable materials from San Diego County's waste stream and process the leftover garbage for fuel. When the plant is completed, it will probably shoot the county's garbage-disposal costs up from the current $3 a ton for landfilling to more than $7.50 a ton for total processing. Yet despite the increased costs, county officials are excited about the new plant. For them, it represents a way out of a garbage dilemma that is plaguing many of the nation's cities: rapidly depleting landfills. And for Garrett, the plant is an entry into an infant but potentially lucrative industry: resource recovery.

Across the country, an increasing number of cities and companies are joining forces to dam the tide of garbage that is overflowing landfill space. Already about 18 solid waste recovery facilities are operating or are under construction in the U. S., and according to the Environmental Protection Agency, their combined capital cost is $338-million. Preliminary or feasibility studies are under way in an additional 19 communities for projects that would total an additional $350-million in capital investment.

Wide-open field. The EPA is way behind in a six-year-old promise to set guidelines that cities could refer to in choosing among waste-handling technologies, and this leaves the field wide open for waste-handling companies to push their products and technology to the forefront. Many will fall by the wayside in the competitive fight. But for those that come out on top, the potential profits are enormous. Even where cities plan to operate and manage the facilities themselves, some companies may profit by selling specific product lines. And for those firms that design and operate the plants, the potential is even greater.

But the profit path is studded with obstacles. Ideally, municipal and EPA funding would provide a cushion for high construction costs. But funds are increasingly scarce, and long-sought federal support is hard to come by. "The Administration tends to think of solid waste as a local problem, and Congress has been reluctant to come up with the kind of money that would be necessary in those areas that need the programs the most," notes Wade St. Clair, vice-president of the National Center for Resource Recovery (NCRR), a nonprofit research organization for stimulating recycling projects.

The nation's top 10 resource-recovery plants

Builder	Location	Size of plant [tons per day]	Investment [millions of dollars]
Union Electric	St. Louis	8,000	$70
Black Clawson	Hempstead, N.Y.	2,000	55
Refuse Energy Systems	Saugus, Mass.	1,200	36
Garrett Research & Development	Bridgeport, Conn.	1,200	29
Combustion Equipment Associates	Berlin, Conn.	1,500	27
American Can	Milwaukee	1,200	18
Enviro-Chem Systems	Baltimore	1,200	16
Combustion Equipment Associates	East Bridgewater, Mass.	700	12
Garrett Research & Development	San Diego	200	10
Waste Management	New Orleans	650	7

Increasingly, companies are having to invest their own funds, and the risks are considerable. The facilities are not only expensive but also take several years to build. There is no return on investment during construction, and costs can spiral. American Can Co.'s Americology Div., for example, had hoped to build and operate an $18-million resource-recovery plant for Milwaukee by midsummer. Delays in getting building permits have pushed that date back to late 1976, and inflation has already ballooned projected operating costs well over original estimates. Even after the plant is working, it will be a while before Americology can hope to make a profit. "It will be a breakeven proposition for about two years, and should start to earn some return around the third year," predicts Lucien C. Bielicki, Americology vice-president.

Not all companies are willing to take the risk. Union Carbide Corp.'s Linde Div. is negotiating with Seattle and Mt. Vernon, N. Y., hoping to sell them the company's Purox system for converting garbage to fuel gas. "We would provide the equipment on an uninstalled basis, although we would be willing to enter into operating agreements," explains Richard Paul, business manager for solid waste systems. "But we don't want to put our own money into the systems."

Still, a growing number of companies see the investment as worth it. Garrett Research & Development, a subsidiary of Occidental Petroleum Corp., will put up $4.5-million of the $10-million cost of its San Diego project. Black Clawson, the Parsons & Whittemore subsidiary that built the EPA's prototype resource-recovery system at Franklin, Ohio, several years ago, is building a $55-million facility to serve Hempstead, N. Y. "The 55-million is a hefty investment," says a company spokesman, "but the technology is proven, and the markets are there for the steam and the recyclable materials."

Potential market. Theoretically, the markets for recovered resources are plentiful. According to the EPA, if all 125-million tons of municipal and industrial waste generated annually in the U. S. were processed through resource-recovery facilities, they would yield the Btu equivalent of 142-million bbl. of oil per year, along with some 14-million tons of steel, aluminum, and copper.

No one questions the marketability of the energy. But many companies, aware of the cyclical nature of the secondary metals market, are seeking metal-market guarantees. Waste Management, Inc.'s Recovery I recycling project in New Orleans was one of the first to establish guaranteed markets. The plant is a joint venture of Waste

Management and the NCRR, and the center's membership, which includes many can and bottle manufacturers, will take most of the output. "They want to prove the viability of the recycling concept," explains Harold Gershowitz, Waste Management's senior vice-president.

Recovery I does not convert refuse to energy, and Gershowitz says the guaranteed metal market is essential to the project's success. The companies in the energy end of the business are less worried. "We built our Brockton (Mass.) plant without a guaranteed user for our fuel, and we would do it again," says Robert M. Beningson, president of Combustion Equipment Associates, Inc., whose Eco-Fuel is a powdered fuel derived entirely from refuse. Companies that are producing steam and electricity by burning refuse, rather than producing a fuel that can be sold anywhere, are more likely to hedge their bets, however. Before they build their facilities, they generally contract with local utilities to take whatever energy they generate.

But even with guaranteed markets, the pitfalls in resource recovery are numerous. For example, air-pollution problems have not yet been ironed out. Raytheon Service Co. just lost out on a $3.2-million contract to build a resource-recovery facility for Lowell, Mass., when the city discovered that it would take $5-million more to bring the plant into compliance with the EPA's particulate emission standards. Monsanto's Enviro-Chem Systems, Inc., is in even worse shape with its $16-million metal-reclamation and pyrolysis plant in Baltimore. The plant has already been built, but its opening is delayed indefinitely because shakedown tests show that it violates EPA rules.

Top contenders. Despite the sobering failures, competition for city contracts is fierce, and several technologies are vying for top spot. Along with different types of magnetic separators to pull out recyclable metals and machines for shredding refuse, there are several different fuel-producing techniques. These include:

- Pyrolysis, which uses heat in the absence of oxygen to convert solid waste into fuel gas or oil.
- Union Carbide's Purox, which uses pure oxygen to produce high-temperature incineration of refuse to yield a clean-burning gas.
- Combustion Equipment Associates' process for making Eco-Fuel, which chemically treats shredded garbage and reduces it to fine-particle size.

Each company, of course, claims that its system is most efficient, and municipalities are taking a "wait and see" attitude before choosing. "Many cities are waiting for tomorrow's announcement that a golden garbage machine that won't cost much has been perfected," says the NCRR's St. Clair.

Open-minded. Most city officials are keeping an open mind. If resource-recovery concepts pan out, they have much to gain. For example, a recent study prepared for Aluminum Co. of America by Franklin Associates estimates that cities could meet operational costs of recovery facilities and still "reduce by nearly 50% the cost of today's disposal options of incineration and landfill, which average $7.10 a ton." Still, cities do not want to chance a fiscal bloodbath by investing in unproven technologies, and they are searching hungrily for data on the few systems that are working. The EPA intends to grant some funds later this year for cities to study available technologies on their own. "This way, it won't be so easy for them to be victimized by gadget salesmen peddling useless systems," explains Thomas F. Williams, director of technical information for the EPA's Solid Waste Recovery Program.

Already about 18 solid waste recovery plants are operating or being built

Queries are going out in droves to recovery-facility directors. Robert A. Horton, director of a project for generating energy from trash to heat and air-condition buildings in Nashville, Tenn., has 10 full-time people fielding questions from other cities and planners. Resource-recovery companies are also noticing flurries of interest—but new contracts remain few and far between. Notes Theodore Buss, sales manager of Monsanto's Enviro-Chem: "We get a lot of tire kickers, but most cities want to wait until the Baltimore project checks out."

In the long run, such hesitancy may prove a boon to the fledgling resource-recovery industry. "A proliferation of systems now would glut the market with recycled materials and lessen chances for fiscal success," says Waste Management's Gershowitz. "Failures are extremely expensive and can deter other communities from resource recovery." Still, even slow growth can mean significant sales. Resource-recovery operations accounted for about 15% of Combustion Equipment Associates' $115-million in sales in fiscal 1975, for example, and company sources indicate that it could grow to 25% within a few years. Notes Beningson: "There are over 115 census areas with more than 400,000 people that would be perfect for systems like ours." But the industry still does not have a sure thing on its hands. As Gershowitz sums it up: "Everyone wants to believe alchemy is here, but there are still unknowns. All the kinks have not been worked out, and it's premature to say this is a truly lucrative concept." ■

The emerging waste-reclamation business

The resource-recovery industry is still too new for any acknowledged leaders to have emerged. But all the contenders for the top spot do have one thing in common: None is a novice at handling solid waste. Some of the companies on the periphery of the new business—those that sell one waste-handling product line rather than design total resource-recovery facilities—hail from the liquid- and air-pollution control areas. But the mainstays of the resource-recovery industry have a long history of competence in solid-waste management.

The best example is Black Clawson, which built and operates the Environmental Protection Agency's demonstration resource-recovery facility at Franklin, Ohio. Other companies come close. American Can Co., for example, has been reclaiming waste for 65 years, says Chairman William F. May. "Our M&T Chemicals subsidiary is a leader in metals reclamation, and we have had extensive experience in retrieving valuable materials from our own recycling operations," he explains.

Flexible. Often resource recovery supplements a company's existing business. "Resource-recovery plants will never make landfills obsolete," maintains Harold Gershowitz, senior vice-president of Waste Management, Inc., which has been in the trash-hauling business since the 1890s. "And even resource-recovery plants have residues that must be disposed of," he adds. Browning-Ferris Industries, Inc., also sees the growing trend to resource recovery as a boon to its existing business of handling solid and liquid wastes. "Waste must still be transported, there will be residues requiring disposal, and someone must operate the plant," notes Tom J. Fatjo, Jr., chairman of Browning-Ferris' executive committee. "All of these areas present opportunities for us."

Familiarity with waste-handling problems enables the companies to tailor their bids to a community's needs. They can add or subtract recovery capabilities at will. For example, some facilities might include glass recycling, while others would find this unprofitable. "Flexibility is the key to success," says Waste Management's Gershowitz. "We will not tie ourselves to one system or one piece of hardware."

(Excerpted from: U.S. Environmental Protection Agency, Third Report to Congress: Resource Recovery and Waste Reduction. Washington: U.S. Government Printing Office, 1975.)

APPENDIX

DESCRIPTION OF SIX EPA-SUPPORTED RESOURCE RECOVERY TECHNOLOGY DEMONSTRATIONS

SHREDDED, CLASSIFIED WASTE AS A COAL SUBSTITUTE—ST. LOUIS, MISSOURI

The city of St. Louis operates facilities to separate shredded organic material from residential solid waste for use as fuel. The fuel is burned with coal in electric utility boilers of the Union Electric Company. Ferrous metal is also recovered and sold to a steelmill. Midwest Research Institute is under contract with EPA to conduct an independent evaluation of the project.

The time and cost schedule for the demonstration is presented in Table 39.

TABLE 39
TIME AND COST SCHEDULE, ST. LOUIS PROJECT

Activity	Time period	Total cost	Federal share of cost
Design and construction	July 1970 to April 1972	$3,288,544	$2,180,026
Operation and evaluation	May 1972 to June 1975*	600,000	400,000
Total		$3,888,544†	$2,580,026

*The project has been extended for additional tests.
†Union Electric Company is to provide $950,000 and the city of St. Louis the remaining $358,518 of the non-Federal share. In addition, EPA is spending about $750,000 to evaluate the project.

The Processing System

The system currently accepts solid waste from residential sources. It was designed to exclude oversized bulky wastes, such as tires, appliances, furniture, engine blocks, and land-clearing and demolition wastes. This limitation is a function of the capacity of the shredders and the fuel quality objective.

The system was designed to handle 325 tons of waste in one 8-hour processing shift and three 8-hour fuel-firing shifts. Raw solid waste is discharged from packer-type collection trucks onto the floor of the receiving building. Front-end loaders push the waste to a receiving belt conveyor. From the receiving conveyor, the waste is transferred to the hammermill, a shredding device.

Shredding reduces residential raw waste to particles that are relatively uniform in size and therefore easier to separate mechanically into salable components. It also reduces odors and facilitates handling.

In the St. Louis shredder, 30 large metal hammers swing around a horizontal shaft, grinding the waste against an iron grate until the particles are small enough to drop through the grate openings. The design calls for a nominal particle size of 1½ inches. Preliminary data show that over 90 percent by weight of the incoming waste is reduced to particles not greater than 1 inch in any dimension.

Single-stage milling (all shredding in one pass through the shredder) was selected for the prototype system to minimize capital costs. For future applications, however, experts recommend a two-stage shredding operation, with air classification between the two stages. The first shredding would reduce the waste to a particle size of about 4 to 8 inches. After removal of the heavier materials by the air classifier, the second shredding would reduce the particle size of the light fraction to 1 or 2 inches.

In the present St. Louis system the shredded waste is conveyed from the hammermill to the air classifier. The air classifier separates the heavier, mostly noncombustible particles from the lighter ones in a vertical chute where a column of air blowing upward

carries the lighter materials to the top. The heavier materials drop to the bottom. By varying the air velocity and the cross-sectional area of the chute, the percentage split between heavy and light fractions can be controlled. The St. Louis air classifier is operated to permit 75 to 80 percent of the shredded waste to be separated into the light fraction for use as fuel.

The light fraction is composed of paper, light cardboard and plastics, textiles, light food wastes, and other organics. There is also a small percentage of light noncombustibles like aluminum foil in this fraction. It also contains small particles of heavier materials, such as pulverized glass, that stick to pieces of organic material.

The heavy fraction contains ferrous and nonferrous metals, glass, dirt, and other noncombustibles. Certain heavier combustible materials, such as citrus fruit rinds and heavier pieces of cardboard, plastics, woodchips, and rubber, also drop into the heavy fraction.

Removal of both the combustible and noncombustible heavy materials from the waste produces three benefits: an increase in the heating value of the waste as fuel, an increase in the transportability of the fuel through the pneumatic pipelines, and a decrease in the boiler's bottom ash. The presence of the small bits of glass and other noncombustible materials remaining in the fuel does not have a significant effect.

The light materials are carried pneumatically from the separation chute to the cyclone separator, where they are removed from the air stream and allowed to fall onto the conveyor leading to the storage bin.

The heavy fraction is passed under a magnetic belt to extract the ferrous metals, which are then densified in a nuggetizer. After passing under a magnetic drum for a final cleanup, the ferrous metals are transported to the Granite City Steel Company where they are used in a blast furnace. The nonmagnetic materials are hauled away to be landfilled.

By recovering fuel and ferrous metal, the city of St. Louis has reduced its landfill volume requirements by 95 percent of the solid waste processed.

At scheduled intervals, quantities of the solid waste fuel are removed from the storage bin at the processing plant and loaded onto trailer trucks for the 18-mile trip to the powerplant. At the powerplant the fuel is unloaded into a receiving bin, which is in turn unloaded continuously into a pneumatic pipeline transport system. These pneumatic pipelines discharge the fuel into a surge bin. The surge bin uses four drag-chain unloading conveyors to move the solid waste fuel to four separate feeders that introduce the supplementary fuel into the pneumatic pipeline system. The pipelines, each about 700 feet long, blow the fuel to firing ports in each corner of the boiler furnace.

The ownership and operating responsibility of the city ends at the point where the city's pneumatic pipelines discharge the fuel into the surge bin owned by the utility.

Operating Experience

Until September 1974, the processing plant operated at about 20 percent of design capacity. Downtime was caused by a variety of factors, including waste collection stoppages resulting from strikes and bad weather, mechanical problems with almost every piece of equipment in the system, and system modifications. Since September 1974, however, the system has operated consistently at 150 to 300 tons per day, 5 days per week, depending upon the requirements of the testing and evaluation program and the availability of the boilers.

Boiler Modification and Operation

Two identical boilers at Union Electric Company's Meramec Plant near St. Louis have been modified to burn prepared solid waste. They are 125 megawatt tangentially suspension-fired boilers that were originally designed to burn pulverized coal or gas. There are now four coal-firing, one solid-waste-firing, and five gas-firing ports in each corner of each boiler.

Other than installing a solid-waste firing port in each corner of the furnace, no modifications to the boilers were made. The prepared solid waste is burned in suspension in the same flame pattern as the pulverized coal.

As is typical of large utility boilers, the furnaces have no grates. Fuels are burned in suspension at temperatures of 2,400 F to 2,600 F. The retention time of 1 to 2 seconds in suspension is not long enough for the heavier particles of combustible materials to be consumed, and they fall to the

bottom ash hopper along with the noncombustible materials.

The two boilers are 20 years old and are small compared to newer units in the Union Electric Company system. They are of modern reheat design, however, and burn 56.5 tons of Illinois coal per hour at rated load.

At rated load, the quantity of solid waste burned in each boiler is equivalent in heating value to 10 percent of the coal and amounts to about 12.5 tons per hour, or 300 tons per 24-hour day. Solid waste is fired 24 hours per day, but only 5 days per week, because city residential solid waste collections are scheduled on a 5-day-per-week basis.

The boiler operators and shift superintendents report that solid waste firing has had no discernible effect on the boiler furnace or convection passes. (Convection passes are hot gas passages containing heat-transfer surfaces between the boiler furnace and the air pollution control equipment.) Frequent and sudden interruptions of the solid waste feed have not required any change in operating techniques. Existing boiler combustion controls easily accommodate the variations in solid waste quantity and quality by varying the amount of pulverized coal fired into the boiler.

The boiler's efficiency or power-producing capability when firing solid waste in combination with coal is reduced slightly compared to "coal only" performance.

Firing solid waste significantly increases the quantity of bottom ash produced, requiring the boiler operators to remove the ash from the hopper more frequently than when coal is fired alone.

Air Emissions from Combined Firing of Waste and Coal

Air emission tests were performed independently by Midwest Research Institute (MRI) from October through December 1973 as part of EPA's comprehensive evaluation of the project. The Union Electric Company (UE) also performed air emission tests during the same period. MRI employed the EPA-approved testing method to measure particulate and gaseous emissions. Union Electric employed the American Society of Mechanical Engineers testing method to measure particulates only.

The results of the MRI tests are summarized in the *St. Louis/Union Electric Refuse Firing Demonstration Air Pollution Test Report*, September 1974, available from the National Technical Information Service, U.S. Department of Commerce.

From the MRI tests it appears that gaseous emissions (sulfur oxides, nitrogen oxides, hydrogen chlorides, and mercury vapor) are not significantly affected by combined firing of waste and coal.

Both MRI and UE tests found that particulate levels per cubic foot of exhaust gas at the inlet to the air pollution control device (the electrostatic precipitators) were not affected by combined firing; however, total inlet particulate levels did increase because of increases in the stack gas flowrate.

The MRI tests did not find an increase in particulate emissions when solid waste was combined with coal. The UE tests, however, did find an increase in such emissions. Therefore, the report is not conclusive on this subject. Also, there is evidence to indicate that neither set of tests provides an optimum representation of combined firing of solid waste and coal. It appears that the electrostatic precipitator was not properly conditioned prior to the tests and could have been tuned for better particulate collection performance.

The report recommends that further tests be conducted to complete the characterization of particulate emissions and to support the development of Federal and State air emission control standards. In response to this recommendation, a second series of tests, conducted independently by EPA and UE, were initiated in late 1974 and are expected to be completed by late 1975.

Economics

The cost of the facilities was about $3 million when they were constructed in 1971. Gross operation and maintenance costs (excluding amortization and interest) for the city and Union Electric Company, based on operating experience from July 1972 to November 1974, are $5.90 per ton of solid waste processed, and $8.50 per ton of solid waste fuel burned, respectively. During this time, the facilities operated at about 30 percent of the 5-day-week single-shift capacity. Consequently, the unit operating costs could be expected to be substantially lower when the plant is operated at design capacity.

However, a higher capital investment would probably be required to achieve greater reliability.

These figures are not at all representative of the cost of a supplementary fuel system to be built elsewhere. In addition to the effect of inflation (about 15 to 20 percent per year for many construction materials), site-specific factors will dictate the economic feasibility of a system. The cost would range from as little as $5 or $8 per ton, to a prohibitively high figure. The major site-specific factors are: characteristics of waste fuel market (distance to boiler, boiler size, load factor, air pollution control equipment, price of primary fuel); characteristics of markets for recovered metals and glass (distance, price, stability, quantity in waste stream); plant capacity (waste available, equipment redundancy, operating shifts per day, operating days per year); method of financing (public or private capital); and the cost of alternative means of waste disposal.

A more comprehensive discussion of the economics of resource recovery systems is presented in Chapter 5.

PYROLYSIS FOR STEAM GENERATION– BALTIMORE, MARYLAND

With the aid of an EPA demonstration grant, the city of Baltimore owns and operates a 1,000-ton-per-day solid waste pyrolysis plant developed by Monsanto Enviro-Chem Systems, Inc. The system was designed and constructed by Monsanto under a turnkey contract with money-back performance guarantee provisions. Monsanto has guaranteed plant availability at 85 percent, particulate emissions to meet local and Federal standards, and the putrescible content of the residue to be less than 0.2 percent. Monsanto's maximum payback liability is $4 million, about 25 percent of the contract price. The time and cost schedule for design, construction, operation, and evaluation is given in Table 40.

The plant is designed to handle mixed municipal solid waste, including tires and white goods. All incoming wastes are shredded to a 4-inch particle size and then conveyed to a rotary pyrolysis kiln. About 7.1 gallons of No. 2 fuel oil per incoming ton of waste is combusted to provide heat for the pyrolysis reaction. In addition, about 40 percent of the amount of air theoretically required for complete combustion is added to the reactor to allow some of the pyrolysis gases to combust and add additional heat to the unit. The remaining pyrolysis gases leave the kiln and are then combusted in an afterburner. The hot afterburner exhaust gases pass through waste heat boilers that generate 200,000 pounds of steam per hour for sale to the Baltimore Gas and Electric Company (Table 41). The steam is used for downtown heating and cooling. Boiler exhaust gases are scrubbed, dehumidified, and released to the atmosphere.

Although the system uses about 7.1 gallons of No. 2 fuel oil per ton of incoming waste, the steam generated from each ton of incoming waste will conserve 39.1 gallons of fuel oil, for a net savings of 32 gallons.

The pyrolysis residue is water-quenched, and ferrous metals are separated for recycling by Metal Cleaning and Processing Company, Inc. Water flotation and screening processes separate the char residue, which is landfilled, from a glassy fraction which will be used as aggregate for city asphalt street construction. Sixteen tons of char with 50 percent moisture is produced for every 100 tons of solid waste input. Air emissions are monitored and controlled to meet local and Federal standards; no wastewater is discharged.

The projected economics for this system, based on February 1974 data, are summarized in Table 42.

PYROLYSIS TO PRODUCE LIQUID FUEL– SAN DIEGO COUNTY, CALIFORNIA

San Diego County will build and operate a 200-ton-per-day pyrolysis plant with the aid of an EPA demonstration grant. The time and cost schedule is presented in Table 43.

The key component of this plant will be a flash pyrolysis unit developed by the Garrett Research and Development Company. Mixed municipal solid waste will be shredded coarsely to a 3-inch particle size and then separated mechanically into two fractions: a "light" fraction consisting mostly of paper and plastic and a "heavy" fraction consisting of glass, metals, wood, and stones.

The light material will be dried and shredded again, to a very fine particle size (practically a powder) and then pyrolyzed at a temperature of about 900 F. This process produces a gas, which is condensed into an oil-like liquid with a heat value

TABLE 40
TIME AND COST SCHEDULE, BALTIMORE PROJECT

Activity	Time period	Total cost*	Federal share of cost
Design and construction	January 1973 to December 1974	$16,177,000	$6,000,000
Shakedown, operation, and evaluation†	January 1975 to December 1976		

*Baltimore is to provide $6,177,000 and Maryland Environmental Services is to provide $4 million of the non-Federal share.
†Length of shakedown period and cost of possible plant modifications cannot be estimated accurately at this time.

TABLE 41
ANTICIPATED OUTPUTS AND MARKET VALUES, BALTIMORE PROJECT

Product	Tons per 100 tons of waste input	Market value per ton sold
Steam	240	$ 4.66
Ferrous metal	7	22.00
Glassy aggregate	17	2.35

about 75 percent that of No. 6 fuel oil. It will be used as supplementary fuel in an existing San Diego Gas and Electric Company boiler.

From the heavy fraction, ferrous metals will be separated by an electromagnet and glass will be separated as a mixed-color glass cullet by a froth flotation process. The anticipated outputs and prices are summarized in Table 44.

When operating at capacity (200 tons per day), 11 tons of char as well as 32 tons of other residuals will require landfilling each day. Exhaust gases will be monitored and controlled to meet local and Federal standards, and wastewater will be discharged into a sanitary sewer.

This system requires no external fuel and produces a storable, transportable fuel that should have good national marketability.

The projected economics of the system are summarized in Table 45.

TABLE 42
PROJECTED SYSTEM ECONOMICS FOR BALTIMORE PROJECT, BASED ON FEBRUARY 1974 DATA*

Item	Value
Capital investment†	$20,000,000
Annual cost:	
Amortization and interest	1,720,500
Operation and maintenance	2,356,000
Total annual cost	$ 4,076,500
Costs and revenues per input ton of solid waste:	
Cost before revenue	$13.15
Revenues:	
Steam	11.18
Ferrous metal	1.55
Glassy aggregate	.40
Total revenues	13.13
Net cost	$ 0.02‡

*Based on a 1,000-ton-per-day operation in which 310,000 tons of raw solid waste are throughput per year.
†Using February 1974 dollars, $20 million of capital is required.
‡Because these are estimates based only on pilot plant experience, the actual costs and revenues may be significantly different.

PROCESSED WASTE AS A FUEL OIL SUBSTITUTE—STATE OF DELAWARE

With the aid of an EPA demonstration grant, the State of Delaware will enter into a full-service contract with a single company that will design, construct, and operate a resource recovery facility to be located in Wilmington. The contractor will be selected competitively after proposals are solicited. The contractor will guarantee plant performance and capital, operating, and maintenance costs.

The plant will be designed to process daily 485 tons of municipal solid waste, 15 tons of industrial

TABLE 43
TIME AND COST SCHEDULE, SAN DIEGO PROJECT

Activity	Time period	Total cost	Federal share of cost
Design	December 1974 to April 1975	$7,423,244	$3,562,710
Construction	August 1975 to May 1976		
Operation and evaluation	June 1976 to December 1977	1,457,795	–
Total		$8,881,039*	$3,562,710

*San Diego County is to provide $1,817,329, and Garrett Research and Development Company is to provide $3,500,000.

TABLE 44
ANTICIPATED OUTPUTS AND PRICES, SAN DIEGO PROJECT (200 TPD PLANT)

Product	Quantity per day	Price
Oil	172 barrels	$4.33 per barrel
Ferrous metal	23.7 tons	18.20 per ton
Glass	10.4 tons	6.40 per ton

TABLE 45
PROJECTED SYSTEM ECONOMICS, SAN DIEGO PROJECT*

Capital investment	$6,344,000
Annual costs:	
Amortization and interest	553,069
Operation and maintenance	916,351
Total annual cost	$1,469,420
Costs and revenues per input ton of solid waste.	
Cost before revenue	$ 23.70
Revenues:	
Oil	3.80
Ferrous metal	2.30
Glass	.40
Total revenues	6.50
Net cost	†$ 17.20

*Based on a 200-ton-per-day operation in which 62,050 tons of raw solid waste are processed per year.

†Because these are estimates based only on pilot plant experience, the actual costs and revenues may be significantly different.

waste, and 230 tons of digested sewage sludge containing 8 percent solids. Incoming municipal solid waste will be shredded to a 6- to 8-inch particle size. The shredded waste will be air-classified into two fractions: a "light" combustible waste fraction containing about 60 to 75 percent of the incoming waste and a "heavy" waste fraction containing metals, glass, wood, heavy plastics, textiles, rubber, and rocks.

The light fraction will be shredded again to a 1-inch particle size. Most of the light fraction will then be sent directly to Delmarva Power and Light Company for use as supplemental fuel in existing oil-fired boilers. The remaining light fraction will be mixed in aerobic digestors with partially dewatered sewage sludge for use as compost or supplemental powerplant fuel, or both, depending upon market conditions.

The heavy fraction will be processed to remove ferrous metals for recycling. The remaining heavy materials will be mixed with selected industrial wastes and pyrolyzed. Heat from the pyrolysis gases will be used to help dewater the sewage sludge. Aluminum and glass will be recovered from the pyrolysis residue. The remaining residues will be landfilled (about 10 percent by weight of the incoming waste).

The State of Delaware has projected the economics of the system based on a preliminary design by Black, Crow, and Eidsness, Inc. EPA has used these projections as a basis for the updated estimates given in Tables 46 and 47. The actual costs of the system will not be known until the fixed price contract is signed in early 1976.

TABLE 46
PROJECTED SYSTEM ECONOMICS
WILMINGTON PROJECT*

Item	Value
Capital investment†	$25 million
Annual costs:	
Amortization and interest‡	2.2 million
Operation and maintenance§	1.7 million
Total annual costs	$ 3.9 million
Costs and revenues per input ton of solid waste:¶	
Cost before revenue	$29.60
Revenues:**	
Humus (compost)	1.10
Solid waste fuel	10.00
Ferrous metal	2.80
Nonferrous metal	.80
Glass	.35
Paper	.10
Sludge disposal credit	1.45
Total revenues	16.60
Net cost	$ 13.00

*These are rough projections by EPA based on earlier estimates developed by Black, Crow and Eidsness, Inc., for the State of Delaware.

†Using 1977 dollars, calculated by escalating 1974 projections at 15 percent per year; includes projected cost of processing plant, fuel transport facilities, fuel receiving and firing facilities, boiler modifications, and air pollution control equipment modifications to the utility's boiler.

‡Assumes capital paid back at 6 percent interest over 20 years.

§Using 1979 dollars, calculated by escalating 1974 projections by 10 percent per year.

¶130,000 tons of waste are to be processed per year.

**Using 1974 dollars.

TABLE 47
ANTICIPATED OUTPUTS AND MARKET VALUES,
WILMINGTON PROJECT*

Product	Tons per day	Market value per ton sold
Humus (compost)	38 (dry)	$ 14.70
Solid waste fuel	305	16.40†
Ferrous metal	35.5	40.00
Nonferrous metal	2	200.00
Glass	25	7.00
Paper	5	10.00
Sludge disposal	18 (dry)	40.00

*Estimates by EPA based on earlier estimates by Black, Crow and Eidsness, Inc., for the State of Delaware; uses 1974 dollars.

†Assumes fuel oil costs $2.00 per million Btu, and that solid waste fuel has a heat value of 5,000 Btu/lb, or 10 million Btu/ton. Value of fuel is discounted to reflect the boiler efficiency loss when firing waste. Efficiency loss is assumed to be 2 percent (a conservative figure, based on EPA conversations with boiler manufacturers).

The total cost of the project is estimated to be about $28 million, with the EPA grant covering $9 million of the costs (see Table 48 for cost and time schedule). If the full-service contract is initiated on schedule by August 1976, the system should be fully operational by April 1980.

WET PULPING FOR MATERIALS RECOVERY – FRANKLIN, OHIO

The objective of this project is to demonstrate a refuse disposal and resource recovery system capable of processing municipal refuse and producing metals, color-sorted glass, and paper fiber in a recyclable form. Nonrecoverable combustible materials are incinerated in a fluidized bed reactor. Noncombustible rejects are landfilled. The time and cost schedule for design, construction, and operation is given in Table 49.

The total system, with a design capacity of 150 tons per 24-hour day, contains three separate subsystems: a processing and disposal system for solid waste and sewage sludge with recovery of ferrous metal, a glass and aluminum recovery system, and a paper fiber recovery system.

The disposal system consists primarily of a wet pulper ("hydrapulper"), a liquid cyclone, and a fluidized bed incinerator. Ferrous metal is recovered through magnetic separation and sold as scrap to a steelmill.

The glass and aluminum subsystem uses a complex series of mechanical screening and classifying operations to extract a glass-rich stream and an aluminum-rich stream from the heavier materials in the waste. Optical sorters separate the glass into flint, green, and amber particles for use in making new bottles.

The fiber recovery subsystem recovers paper fiber from the lighter combustible materials in the waste stream. Fiber is recovered through the use of several screening and cleaning operations. It is then pumped in slurry form to a nearby papermill through an underground pipe. The fiber is used in making felt paper for asphalt roofing shingles.

TABLE 48
TIME AND COST SCHEDULE, WILMINGTON PROJECT

Activity	Time period	Total cost	Federal share of cost
Design and construction	August 1976 to August 1979	$25,000,000	$6,755,000
Startup	August 1979 to April 1980	328,000	245,000
Operation and evaluation	April 1980 to April 1981	2,700,000	2,000,000
Total		$28,028,000	$9,000,000

TABLE 49
TIME AND COST SCHEDULE, FRANKLIN PROJECT

Phase and activity	Time period	Total cost	Federal share of cost
Hydraposal and fiber recovery systems:			
Design	March 1969 to February 1970	$ 165,000	$ 110,000
Construction	March 1970 to June 1971	1,970,000	1,300,000
Operation and evaluation	June 1971 to August 1972	500,000	350,000
Subtotal		2,635,000	1,760,000
Glass and Aluminum Recovery System:			
Design	July 1971 to May 1972	20,000	60,000
Construction	May 1972 to July 1973	360,000	257,000
Operation and evaluation	July 1973 to February 1976	90,000	77,000
Subtotal		470,000	394,000
Total		$3,105,000*	$2,154,000

*Approximate non-Federal contributions: the city of Franklin, $500,000; the Black Clawson Company, $200,000; and the Glass Container Manufacturers Institute, $150,000.

System outputs are shown in Table 50.

All combustible residues, as well as sludge from an adjacent sewage treatment plant, are disposed of in the fluidized bed incinerator.

All noncombustible rejects (approximately 10 percent by weight of the total incoming wastes) are disposed of in a small sanitary landfill adjacent to the plant. Air emissions from the fluid bed incinerator have been found to be below the Federal standards. All water effluents from the plant are discharged into the adjacent sewage treatment plant.

TABLE 50
PRODUCT OUTPUTS AND PRICES, FRANKLIN PROJECT

Product	Tons per 100 tons of waste input	Price per ton sold
Ferrous metal	9	$ 25
Paper fiber	20	42
Glass (color-sorted)	4	20
Aluminum	.3	200

The projected system economics for a 500-ton-per-day facility are summarized in Table 51.

TABLE 51
PROJECTED ECONOMICS FOR 500-TON-PER-DAY FRANKLIN-TYPE SYSTEM*

Item	Value
Capital investment	$10,600,000
Annual costs:	
Amortization and interest†	1,350,000
Operations and maintenance	1,286,868
Total annual costs	$ 2,636,868
Costs and revenues per input ton of solid waste:	
Cost before revenue	$ 20.42
Revenues:‡	
Ferrous metal	2.40
Paper fiber	8.06
Sewage sludge disposal credit	1.75
Total revenues	12.21
Net cost	$ 8.21

*Based on a three-shift operation in which 150,000 tons of raw solid waste are throughput per year. The Franklin plant processes approximately 50 tons per day.
†Based on 20-year depreciation.
‡Does not include glass and aluminum recovery.

MATERIALS RECOVERY FROM INCINERATOR RESIDUE–LOWELL, MASSACHUSETTS

In this project, the city of Lowell was to build a full-size processing plant capable of recovering materials from 250 tons of incinerator residue, which represents about 750 tons of raw waste, each 8-hour day (Table 52). In July 1975, however, the city requested withdrawal from the demonstration, and the project was therefore terminated. The reason for the withdrawal was that the city decided to close down their incinerator rather than undertake very expensive capital improvements for air pollution control.

The primary objective of the project was to demonstrate the technical and economic feasibility of a mechanical separation system for recovering metals and glass from the noncombustible portion of solid wastes. Initially, these products were to be recovered from incinerator residues, but the system was also designed to handle noncombustible solid wastes that have been separated from the combustible fraction by air classification or some other means.

The design for the plant was prepared by the Raytheon Company using the system piloted by the U.S. Bureau of Mines at College Park, Maryland. The system uses a series of screens, shredders, classifiers, and other ore-processing equipment to extract steel, nonferrous metals, and glass from the incinerator residue. The project plans for Lowell called for recovery of more than 40,000 tons of products annually which would result in revenues of some $700,000 a year (Tables 53 and 54). Depending on the level of burnout in the incinerator residue, about 5 tons of solid residue per 100 tons of incinerator residue input would be landfilled. No gaseous pollutants would be emitted from the processing plant, and process water would be treated in the plant before being discharged into the city's sanitary sewer system.

TABLE 52
TIME AND COST SCHEDULE, LOWELL PROJECT (CANCELLED JULY 1975)

Activity	Time period	Total cost*	Federal share of cost
Design, construction management	February 1973–December 1974	$ 798,000	$ 325,000
Construction	January 1975–March 1976	3,321,000	1,434,000
Operation and evaluation	April 1976–March 1977	734,000	625,000
Total		$4,853,000	$2,384,000

*The State of Massachusetts was to provide a total of $615,000, and the city of Lowell, $1,854,000 plus $180,000 in land value for the facility site.

TABLE 53
ESTIMATED SYSTEM OUTPUTS AND PRICES, LOWELL PROJECT

Product	Tons per 100 tons of input*	Price per ton sold
Ferrous metal	30	$ 33
Aluminum	2	250
Copper/zinc	1	330
Glass	30	23
Aggregate	32	2

*Incinerator residue.

TABLE 54
PROJECTED SYSTEM ECONOMICS, LOWELL PROJECT*

Item	Value
Capital investment	$4,119,000
Annual costs:	
Amortization and interest	424,000
Operation and maintenance	734,000
Total annual costs	$1,158.000
Costs and revenues per ton of input (incinerator residue):	
Cost before revenue	$ 17.80
Revenues:	
Ferrous metal	4.80
Aluminum	3.12
Copper/zinc	2.08
Glass	6.75
Aggregate	.50
Total revenues	17.25
Net cost	$ 0.55

*Based on a one-shift, 250-ton-per-day operation in which 65,000 tons of incinerator residue are throughput per year.

ENERGY

Power from trash: A solution with problems

Over the past few years the nation's cities and electric utilities have grown more and more interested in what has seemed like an ideal way to reduce their waste disposal and power problems in one stroke: burning trash in power plant boilers. According to one study by Chase Manhattan Bank, using trash for fuel could one day almost eliminate the need for costly landfills while saving the U. S. perhaps as much as 280,000 bbl. of oil a day. But suddenly, major economic and technical problems are cropping up that could throw such high hopes onto the garbage heap.

The problems are most visible in St. Louis, where the nation's showcase trash-to-power experiment has been conducted with the eager assistance of Union Electric Co. From 1972 through 1975 the Environmental Protection Agency contributed $3 million to help the city build and operate a trash processing plant capable of preparing 250 tons of refuse a day for one of the utility's boilers. The company spent an additional $600,000 to modify a coal-fired unit to accept the trash and burned some 60,000 tons of it during the three-year program, saving about 20,000 tons of coal. But the EPA has found that trash power is a solution that raises other problems.

Don Rutledge

Questionable resource. Garbage to fuel utility boilers seemed ideal—but now there are second thoughts.

Gas and ash. "The big unknown is what the pollution control costs will be," says James Kilgroe, an air pollution project officer at the EPA. The agency discovered that burning refuse can create big volumes of gas that hamper a power plant's electrostatic precipitators, which are designed to control particulate emissions. The gases can cause a drop in precipitator performance when the main fuel burned is high-sulfur coal. Precipitators normally work better with such coal because the sulfur content helps place a charge on the unwanted soot, but the gases dilute this effect. Unfortunately, high-sulfur coal is the kind most readily available to Union Electric and other Midwest and Eastern utilities. So using garbage for fuel could put them in violation of air quality standards. The refuse also increased Union Electric's ash removal problems. "We got four to seven times the residue over straight coal burns," says a disappointed Kilgroe.

Another—and potentially more serious—problem also was uncovered. Dust samples emitted from the processing plant showed bacteria counts of 1 million per cu. ft. compared with counts of one or less 20 mi. away. The bacteria and virus, including salmonella and fecal coliform, could pose a health problem. "We don't know if the bacteria are harmful, the die-off time when they are dispersed, or even if filters could eliminate them," cautions Robert Holloway, an EPA engineer. "But it is definitely a matter for concern."

Possible health hazard: The process emits high bacteria counts

One solution might be to follow the French example by retrofitting incinerators to make steam. Bacteria would die in the high temperatures, and the steam could be sold to both utilities and commercial buildings, which could use it for heating and air conditioning. This approach, however, would do nothing to alleviate the additional air pollution from the refuse.

Despite the problems, Union Electric remains optimistic. The company wants to build four trash processing facilities, at a total cost of $68 million, to treat 2.5 million tons annually—the entire output of the St. Louis metropolitan area. But the company wants to be paid for taking the trash off the city's hands, and St. Louis has balked at the idea. And now that the EPA demonstration program is over, the city refuses to supply the utility with any more trash. "This is a big problem everywhere," says Morris Zusman, of the Federal Energy Administration's conservation office. "The economics are not clear enough on who should pay whom."

A recent study of trash-burning power stations by the Tennessee Valley Authority concludes that the TVA would have to get from $5.90 to $10.70 per ton of refuse to make its use as a fuel economic. TVA also concluded that a processing facility would cost $35 million—nearly twice as much as some projections have indicated. "A lot depends on whether you're the buyer or the seller," advises TVA planning chief David A. Patterson.

Differing views. Other utilities are just as bearish. New York's Consolidated Edison Co. has concluded that to burn trash in its oil-fired Arthur Kill generating station would require a $2 a ton subsidy from the city. Says Engineering Vice-President Carl L. Newman: "The economics are disappointing." The FEA tends to agree. Right now, says Zusman, "the main incentive to burn trash is good public relations."

Not everyone is quite so cynical. Officials in Chicago have agreed to sell some of the city's trash to Commonwealth Edison Co. for $3.60 a ton. The utility expects to buy 700 tons daily, saving the city the $40 million it would have to raise for a new incinerator and lowering its current trash handling costs of $14.60 a ton.

Studies currently under way at both the EPA and the FEA indicate that processing trash into boiler fuel should eventually prove feasible where large amounts of refuse can be easily collected and the local utility has coal-burning facilities. And according to *Electrical Week*, a utility industry newsletter, more than 75 U. S. cities are still contemplating some kind of trash-to-power project. ■

(Excerpted from: U.S. General Accounting Office, Using Solid Waste to Conserve Resources and to Create Energy. Washington: U.S. General Accounting Office, 1975.)

Delaware project

In response to EPA's March 1972 solicitation for pre-proposals for resource recovery demonstration projects, Delaware submitted an application proposing a project whose principal product was to be humus, an agricultural-horticultural product used in growing plants and crops. Delaware proposed to market the humus principally for use in growing mushrooms. The process was also intended to recover ferrous and nonferrous metals, glass, and carbon and to produce fuel to operate the driers used in producing humus.

In a letter dated June 15, 1972, EPA notified the State not to invest its time and effort in submitting a formal application. EPA took that position primarily because the proposed system was considered economically unfeasible for the area served because (1) purchase commitments were not obtainable for the humus product and (2) the system would have little nationwide applicability due to its limited product marketability. These reasons were in accordance with EPA's criteria for awarding resource recovery demonstration grants.

Nevertheless, Delaware submitted a formal application which EPA reviewed with the 16 other formal applications. EPA ranked the Delaware project 13th in comparison with the other applications. On September 8, 1972, EPA notified the State that it was unable to approve its application basically because of the relatively unattractive economics of the proposed system and because it appeared the system to be demonstrated could not be duplicated in communities throughout the country.

On this same date--September 8, 1972--EPA awarded three resource recovery demonstration grants for projects to Lowell, San Diego County, and Baltimore. The award of these three grants obligated $11.4 million of the $11.5 million appropriated for the demonstration grants. On August 22, 1972, a bill had been enacted which appropriated an additional $15 million for demonstration projects, and in October 1972 OMB released $9 million in demonstration grant funds.

On October 20, 1972, the Acting Assistant Administrator, Office of Categorical Programs, sent a memorandum informing

the EPA Administrator of the decision to award the grant. The memorandum stated that throughout the history of the project EPA strongly opposed Delaware's pursuit of a resource recovery facility built around the technology of composting for the principal reason that facilities producing compost had a history of failure. The memo also stated that EPA's reasons for turning down the Delaware application had been: (1) the type of facility proposed had no national applicability, (2) the capital and operating costs of the facility were among the highest proposed, and (3) the facility was basically a compost plant making use of technology which was well known and already demonstrated. On October 26, 1972, EPA awarded a $9 million resource recovery demonstration grant to Delaware for the project which it had previously rejected. The total cost of the project was estimated to be $13.8 million.

We met with the Deputy Assistant Administrator for Solid Waste Management Programs and the Director of the Resource Recovery Division on November 2, 1972, to obtain the rationale for awarding this grant. These officials told us that they believed the $11.5 million which had been appropriated in fiscal year 1972 to fund section 208 demonstration projects was sufficient to fund all of the technology which they felt appropriate to demonstrate. They said that, when the additional $15 million was appropriated, the decision was made to demonstrate technology different from what they were planning to fund under the other three grants which was basically technology for the recovery of materials or energy through some form of combustion. These officials also said, of the final applications received, composting was the only process that was different from the projects being funded. There were only two composting projects submitted and one was too small for demonstration. Therefore, the Delaware project was selected.

A condition to the grant agreement required Delaware to satisfy EPA that no adverse health effects would result from using the humus product in growing mushrooms; no consideration was to be given to funding the project beyond the design stage until this condition was resolved.

In August 1973 EPA informed the State that the Food and Drug Administration of the Department of Health, Education, and Welfare, upon analyzing preliminary data received from Delaware, was particularly alarmed by the high levels of mercury and lead concentrations that would be in the humus. EPA further stated that the use of humus as a mushroom compost ingredient faced many obstacles and its use in any agricultural market may be questionable.

EPA stated that the demonstration of the use of compost as a fuel as suggested by the State was unacceptable and that if the State wanted to market waste as a fuel the system under use by St. Louis which used shredded waste as a fuel (see p. 17) should be considered instead of an expensive composting system.

EPA felt that the State had three options. One option was for the State to further analyze the health aspects of the humus before proceeding any further with the project. The second option was for the State to proceed with the design of the project and conduct comprehensive health-effects testing. Both of these options would require additional expenditures by the State without assurance of subsequent EPA funding.

The third option provided for EPA funding and was accepted. EPA informed the State that it could change the scope of its project to demonstrate a solid waste fuel recovery system similar to the St. Louis project's and EPA could fund the project at 75 percent of the total cost--maximum allowed under the grant program--or $9 million, whichever was less.

In an April 1974 discussion with EPA's Chief, Grants Operations Branch, Grants Administration Division, we pointed out that the three previous demonstration grants were based on evaluations of competitive proposals and the need to demonstrate previously undemonstrated resource recovery systems. Since the Delaware project had evolved into a project similar to the successful St. Louis project which is being actively considered for adoption by other municipalities, we questioned whether the continued funding of the project would effectively further the objectives of the resource recovery demonstration grant program.

We were informed that EPA planned to go ahead with the funding of the $9 million demonstration grant to Delaware for the revised project. EPA officials stated that the only significant change in the project was the shift from production of humus to production of energy. In addition, any humus that will be produced will not be used in connection with food products.

EPA officials informed us that due to inflation the total project cost had increased from an estimated $13.8 million to over $17 million. To insure 75 percent funding of the project EPA agreed to support Delaware's attempts to obtain an EPA water construction grant of approximately $4 million to fund the sewage sludge portion of the facility. At the time of the original award, the project's sewage sludge system would have been funded from the $9 million

demonstration grant. EPA is finalizing an amended grant agreement for the Delaware project containing special conditions which the State must meet to insure Federal funding.

According to EPA grant documents, the estimated cost of the project has increased from $13.8 to $17.4 million and we have been advised it probably will go higher. Although EPA's solid waste funding has not increased, the Federal share has by the proposed use of $4.1 million in municipal waste water treatment construction funds. This brings EPA's total estimated share to $13.1 million. However, the State's contribution of the eligible costs has decreased from $4.7 to $4.4 million. EPA officials said that the State was to pay for all cost overruns. The exception would be the cost attributable to any overruns on the water construction grant, which is to be for the sewage-sludge portion of the facility. Any overruns on that grant, which the State anticipates receiving, would be shared between EPA--75 percent--and the State--25 percent.

The EPA project officer acknowledged that the Delaware project (as amended) was similar to the on-going, EPA funded St. Louis project in that prepared solid waste will be used to supplement fuel in existing steam-electric boilers. However, he stated that a major difference between the two projects was that the boilers in St. Louis burn coal and the boilers in Delaware burn oil. He believes that, because most utilities in the Northeast burn oil and because the Northeast has a critical solid waste disposal problem, an evaluation of such a system would be valuable.

The project officer also believes that the proposed Delaware project will be valuable because it will have the capability of composting sewage sludge with solid waste to produce a pathogen-free humus at a lower cost than that of other available sludge disposal alternatives. Finally, he believes that the project will demonstrate maximum recovery of materials and energy which will reduce the amount of residue to be landfilled.

Connecticut and others are planning to implement systems similar to the Delaware project's where waste fuels will be burned in oil-fired boilers. An example is a planned project for Bridgeport, Connecticut, being designed, constructed, and operated by a private contractor. The Bridgeport system is expected to be operating in 1977, 2 years before the Delaware project. Therefore a question arises whether EPA should proceed further with the Delaware contract at this time in the absence of definite knowledge that appropriate arrangements cannot be made to obtain the pertinent data from the Bridgeport project.

However, EPA is proceeding with the Delaware project without making any effort to determine whether pertinent data on the Bridgeport system could be obtained from the parties involved to enable it to determine the technical and economical feasibility of such systems. We believe that if such an agreement were successful it would provide EPA with an evaluation of the system at an earlier date and at substantially less cost to the Federal Government.

While EPA is finalizing the amended grant agreement for the Delaware project--over 2 years after the original award--Delaware is in the process of preparing a Request for Proposal to select a contractor for the project.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OCT 31 1974

Mr. Henry Eschwege
Director, Resources and Economic
Development Division
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Eschwege:

We have reviewed your draft report on resource recovery and recycling and are in complete agreement with your recommendation to provide expanded assistance to states and local communities through the establishment of resource recovery systems. The following comments address the other portions of the report.

Delaware Demonstration Grant

Regarding the resource recovery demonstration project in Delaware, three points are raised in the report:

1. Confusion over the reasons for the original funding of the project.

2. A question as to whether the proposed modifications to the project are consistent with the competitive award of the other three resource recovery grants.

3. An uncertainty of the value of the project in light of its similarity to the on-going St. Louis EPA demonstration project and the similarity to the State-financed facility planned for Bridgeport, Connecticut, that would be available for evaluation two years before the Delaware project.

We have made detailed comments to GAO on this subject in an August 1974 letter. I would just like to summarize our position.

Justification for Funding. The funding of Section 208 demonstration grants followed an orderly process consisting of solicitation for preapplications, receipt of preapplications, solicitation for formal application, evaluation of the formal applications against criteria, and selection of projects.

Of the 17 applications, only three were recommended for funding because no additional funds were available. The Delaware project was not one of these although it did meet the criteria published in the initial solicitation. The rejection of the Delaware application did not indicate a value judgement on the project per se.

APPENDIX I

In October 1972, the Office of Management and Budget released an additional $9 million in Section 208 funds. At this point an additional (fourth) demonstration grant application was selected for funding, the Delaware Reclamation Project.

The Delaware grant clearly met all the legal and programmatic requirements for funding, although it was not as attractive as the first three projects selected. However, it was selected from among the 14 projects not funded initially. Of the remaining applications, only three were found to be good condidates at the time when additional funds were released. These three projects were in Delaware; Malden, Massachusetts; and Mount Vernon, New York. Both the Mount Vernon and Malden projects were similar to the Delaware project having high costs; both were energy recovery projects; and both had been initially disapproved for this and other reasons. Malden also presented an additional problem in that, under Section 208, care must be taken to ensure distribution of funds among states, and a project in Lowell, Massachusetts had already been approved.

No formal decision process was followed in selecting the Delaware project, as had been followed in the initial recommended actions, but both programmatically and legally the choice was correct.

Project Modifications. The proposed modifications of this project are:

1. A change in project schedule caused by the two years' delay due to negotiations over the Grant Agreement Special Conditions.

2. The use of EPA Water Program Funds for a substantial amount of the State's share of project costs.

3. Modifications in the technology.

The modification to the technology involves adding an air classifier to the system to separate some combustible material to be used as fuel in electric utility boilers. The remaining combustible material would be composted as originally proposed. The modified plant would produce about 70 tons per day of compost for agricultural markets and 200 tons per day of classified solid fuel.

We do not feel that any of these changes warrant a resolicitation of proposals to award competitively the $9 million originally awarded to

the grantee. Such changes are essentially routine and typical of any large-scale solid waste demonstration project. Schedules, budgets, and specific unit processes must be flexible for these innovative systems.

Value of Project. The value of this project is:

1. It will demonstrate burning of solid waste in oil-fired boilers.

2. It will demonstrate composting of sewage sludge with solid waste to produce a pathogen-free humus.

3. It will demonstrate maximum recovery of energy and materials to reduce residue requiring landfilling to a minimum.

This is clearly an extension of the state-of-the-art of resource recovery beyond both the EPA St. Louis demonstration and the State project in Bridgeport, Connecticut.

While we accept responsibility for the initial delays in the implementation of the resource recovery program, we feel the program currently has a strong technical base, is well organized and is moving ahead positively. Your report reflects this progress and we appreciate having had the opportunity to review it.

Sincerely yours,

Alvin L. Alm
Assistant Administrator
for Planning and Management

(Excerpted from: U.S. House of Representatives, Committee on Interstate and Foreign Commerce, Solid Waste Disposal Act Extension - 1974, Hearings, March 27-28, 1974. Washington: U.S. Government Printing Office, 1974.)

Mr. ROGERS. Our next witness is Mr. William C. Dell, executive vice president, Combustion Power Co., Inc., Washington.

STATEMENT OF WILLIAM C. DELL, EXECUTIVE VICE PRESIDENT, COMBUSTION POWER CO., INC.

Mr. DELL. Thank you, Mr. Chairman. I have had the opportunity to testify before this committee before.

Mr. ROGERS. Yes. We remember.

Mr. DELL. I have made available a brochure.

Mr. Chairman, members of the committee. Successful demonstration of the full-scale CPU-400 gas-turbine system for material recycling and utilization of municipal wastes as nonpolluting fuel for the generation of electricity will require authorization and appropriation of approximately $12 million of R. & D. funds over 3 years commencing in fiscal year 1975.

The demonstration plant will be the end product of 7 years' research and development effort in new combustion technology financed by the Government at a cost of nearly $8 million. It will be an environmentally-safeguarded unit serving a population of 250,000. The electric power return will meet the total requirements of up to 10 percent of the population served.

Members of the Congress who have supported and overseen the CPU-400 project are desirous, no doubt, of its completion on a timely basis. We are at that threshold now.

Several years ago, when research and development work was progressing through the throes of infancy, Congress was bent on pushing forward, as expressed in the language accompanying the Resources Recovery Act of 1970:

> The committee was particularly interested in research efforts to produce electrical energy using municipal wastes as the fuel.
>
> One method under study, for example, will reduce waste disposal cost to $1 per ton as compared to clean incineration costs of $6 to $8 per ton. This reduction results from the value of recovered electric energy and the other recoverable materials.
>
> The cost of development of the system through the full scale operating prototype is approximately $19.5 million. It is the type of technological development which should be considered for funding under this section.

It now appears that the overall cost for completion of the CPU-400 project will be about $20 million. The cost of the project has not escalated over the years.

We would hope that the system would be made available to all communities upon completion of the federally-funded demonstration, but, hopefully, with continued Federal Government interest.

The pilot plant for the CPU-400 is located in Menlo Park, Calif., and has been under the supervision of EPA for several years. It has been utilized to incinerate random loads of municipal wastes collected by nearby communities.

As of this moment, the system has a proven performance record for incinerating normal-type municipal waste, well inside existing pollution limits. The combustion technology utilizing a pressurized fluid-bed has been thoroughly examined and found worthy by EPA. The computerized fully-automatic system for taking the refuse from the dump truck and through every cycle has been proven. In this process,

the refuse is pulverized and automatically sorted, with reclaimable metals and glass removed from the combustible portion for reuse.

Remaining R. & D. now being negotiated with EPA, will be devoted to eliminating deposits on the turbine blades which occur in the power generation cycle. This essentially is the result of molten micron-sized pellets of aluminum that are not fully oxidized carried in the hot gas flow. A newly-invented granular filter, which has been successfully tested in subscale over the past few months, will be employed to overcome this remaining problem. The plant will be back in full tests with the filter in place by November of this year. The filtering system will virtually remove all particulate matter, making the system even more acceptable from an environmental standpoint.

Other requirements of the original program have been completed. In brief:

Air pollution emission standards of 0.03 grains/standard cubic foot have been met and will be far exceeded with the incorporation of the granular filter.

Combustion efficiencies of over 99.5 percent have been achieved.

Exhaust gases have been controlled to below 30 ppm for carbon monoxide; below 20 ppm for sulfur dioxide; 138 ppm for nitrogen oxides; and 161 ppm for hydrogen chloride.

Finally, the CPU–400 pilot plant has additionally been used to demonstrate making electric power from hog fuels (wood waste) in cooperation with EPA and the Weyerhaeuser Co.; it will again be used to safely burn high-sulfur coal in a demonstration project now underway sponsored by the Office of Coal Research in cooperation with EPA. Both of these tests involve the generation of electricity through the same gas-turbine system used in the garbage tests.

It should be re-emphasized that this program from its inception has been and remains a Government-sponsored R. & D. contract. The pilot plant in Menlo Park and all of the sophisticated test equipment is wholly-owned by the U.S. Government as well as the patents that have resulted from this work. The program has been completely open and fully reported, and Combustion Power Co. has no exclusive domestic rights to the system.

The CPU–400 project was undertaken to make a giant step forward in the state-of-the-art of municipal waste recycle and energy recovery. Both the combustion technology and the use of a gas turbine represent a significant adventure in this kind of work.

Mr. Chairman, yesterday I had the opportunity to hear the EPA testimony by Mr. Russell Train and Mr. Arsen Darnay. If it is agreeable to you, I would like to make a few additional comments specifically related to that testimony.

Mr. Rogers. All right, it is my understanding from our questioning yesterday they are prepared to proceed after your filter has been demonstrated.

Mr. Dell. First, Mr. Darnay described the CPU–400 project as one that has had considerable technical difficulties. I think a more positive way to put this is that the CPU–400 system is technically the most advanced solid waste recycling and energy recovery system in development in the free world today. We expected to have technical problems in this development, and we now believe that we are on the verge of solving them all. Of course, if we encounter an unsolvable technical problem, the program should, and would, stop.

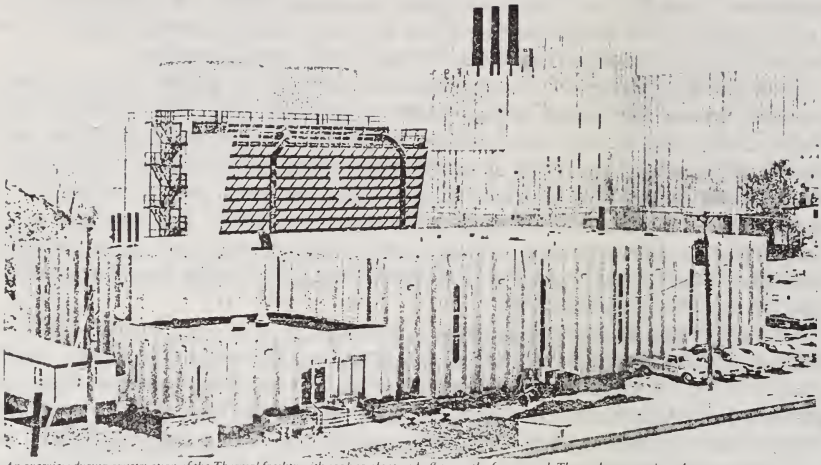
Mr. Darnay also testified that the newly-invented filter must work but there is concern about temperature and pressure losses. Our subscale test thus far on the new filter indicates that the pressure drops and temperature losses in the filter are completely acceptable. We see no problems in proceeding with its full-scale development.

In the beginning of this program, there was great concern as to whether we could burn solid waste in a fluid-bed. We accomplished that. Then there was concern as to whether we could process solid waste adequately in large quantities to feed a fluid-bed combustor—we accomplished that. Then there was concern as to whether we could control the combustion process adequately to operate a gas turbine—we accomplished that. Now there is concern as to whether we can remove the small aluminum particles from the hot gases—and we will accomplish that.

Second, and perhaps the most disturbing, Mr. Darnay, in reply to your question as to what are the plans in the event the filter works, stated that no additional funds would be required because the program would then be successful. As I have stated in my prepared testimony, this program was originally proposed as a $19.5 million development effort to build a full-scale plant. If it was to stop with an experimental subscale pilot plant, it should never have been started.

Mr. Rogers. I think the committee feels the press of the intent was that it should be built as a demonstration project. I think the committee will let our feelings be known on that.

Thank you very much. It is encouraging what you have done with the unit. This committee, as you know, has actually seen that and it was most impressive.



Nashville Thermal Transfer Corp

An overview during construction of the Thermal facility with cooling plant and offices in the foreground. The cooling tower is to the left and the incineration building to the right.

NASHVILLE POINTS THE WAY

(Excerpted from: Catalyst, Vol. IV, no. 4, 1975.)

Turns Waste Into Fuel Without Pollution

by **Carl Avers.**
General Manager & Chief Engineer,
Nashville Thermal Transfer Corporation

Now operating in Nashville, Tennessee is a $16.5 million facility which uses a free and constantly expanding energy source—solid wastes.

Garbage and trash—historically disposed of in dumps and landfills—is utilized in Nashville as a primary fuel in an efficient, modern and economical, central energy plant to heat and cool state, municipal and private buildings in the downtown community.

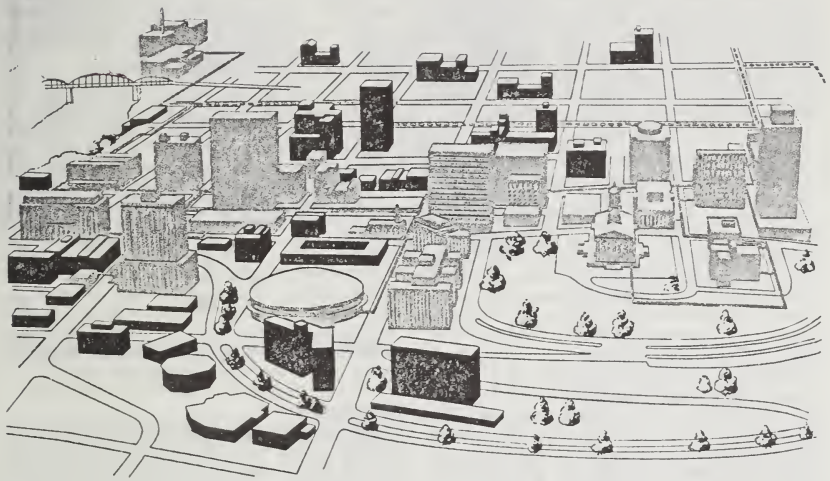
First In the Nation

The plant is the first in the nation to provide both heating and cooling to service downtown office buildings through the incineration of solid waste as a source of energy. Various elements of the project have been applied in other communities, but the Nashville Thermal Transfer Corporation (Thermal) is the first to put it all together.

Visitors are flocking to the site to see this unique system. They come to study, tour, and see first-hand. Included are many League of Women Voters,—who have long shown an interest in the project—and a group of 21 women involved in the construction industry. Probably the largest class of visitors are representatives from other municipalities faced with problems of solid waste management and/or fuel shortages.

Thermal began the delivery of steam heating service in February, 1974 and began fueling with solid waste on May 18, 1974. It is now extending cooling to a number of major downtown office buildings. The plant will ultimately consume 1,440 tons of solid waste daily and provide heating and cooling service to 24 private buildings and 18 government buildings.

The State of Tennessee will be the largest single user with the Metropolitan Government of Nashville a close second. A complex of Federal buildings is expected to join the lengthening list of users, and private buildings already account for over half of the total service consumption.



Nashville Thermal Transfer Corp.

Diagram of Central Business District showing Thermal customers (shaded). From the Thermal plant (upper left), the heating and cooling pipelines circle thraugh the dawntawn area. Braken line shows phase 2 distributian.

Projections by I.C. Thomasson & Associates, engineers for the Thermal project, show first year revenues of $1,600,000. Revenues are estimated to exceed $2,600,000 by 1978. The revenue projections reflect the distinct advantage that Thermal has over individually owned and operated cooling and heating systems. Thermal can produce steam for about 30 per cent of the cost of using fossil fuels, and chilled water for about 40 per cent. The district plant replaces at least 27 individual cooling and heating systems in its first phase alone, and will save some 20 million kilowatt hours (kwh) in electrical usage. When the plant is fully operative, it will conserve more than 71 million kwh per year, or roughly the electric power consumption of a residential area of 15,000 people.

Lowest Price

Thermal's rates for cooling, heating and incineration service will be the lowest in the United States for a system of comparable size. The use of no-cost fuel supplied by Nashville will enable Thermal's customers to purchase heating and cooling for a price at least 25 per cent less than their alternate cost of owning, maintaining and operating their own in-building boilers and chillers.

Under the Thermal-Nashville contract, Nashville retains title to all solid waste delivered to Thermal both before and after incineration. A recent study by the U.S. Bureau of Mines reveals that the recovery value of incinerator ash can equal $2-3 per ton of solid waste. Sale of this residue may result in substantial profits to Nasvhille. Also, this new sytem reduces Nashville's future cost for

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solid waste disposal by about $3 per ton. This saving amounts to over $1,250,000 annually through reductions in the estimated cost of transportation and future sanitary landfill operations.

The initial consumption and production capacity of the Thermal plant will be 720 tons of solid waste per day, producing about 395,000 pounds of steam per hour and approximately 14,000 tons of air conditioning. Ultimately, the plant will consume 1,440 tons of solid waste per day to produce a steam output in excess of 500,000 pounds per hour and over 30,000 tons of refrigeration.

How It Works

The Thermal system begins with local garbage and trash route trucks operating throughout the county. These trucks deliver their solid waste to three strategically located transfer stations where the solid waste is placed in 65 and 75 cubic yard trailers. The solid waste is then delivered to the plant in these large, fully enclosed, semi-trailer trucks and dumped into a refuse pit large enough to permit weekday and weekend operation. One or two deliveries per hour are made to the central plant. The transfer station process significantly reduces annual travel, keeping local trucks off the main roads and permitting them to return to their routes more quickly.

An overhead crane picks up the solid waste in one-ton bites and feeds it into multi-level incinerator-boilers. The plant includes two 360-ton per day steam generators, and eventually will be expanded to include about three additional 360-ton units. These units can also operate on natural gas or fuel oil. The solid waste is continuously fed into the steam generator by moving grates.

Ash from the incinerator is dropped into an ash hopper and sprayed with water from the scrubber tank. Spraying cools the ash and eliminates dust during the removal process. Trucks haul ash from the plant, and the sterile residue ash provides a dense fill or building block material where desirable. If trucked to landfills, it does not require earth cover.

Combustion air, drawn into the plant through the solid waste storage room promotes burning of odors in the steam generator, thus eliminating any potential odor problems in the plant area. The furnace is sealed and operated under a slight negative pressure to prevent escape of dust and odors. The 1,800 degree heat in the furnace explodes glass into tiny fragments much like sand. Metals are sterilized, and can be easily removed from the ash for reclamation.

Pollution Control Important Aspect

For maximum heat recovery, the flue gases exit from the boiler sections through an economizer bank wherein the temperature of the gases is reduced to approximately 500 degrees. These gases then go through sophisticated particulate and gas collection devices in order to meet emission criteria.

Pollution control is a very important part of the project. Very low particulate matter and sulfur dioxide emission rates are accomplished with the combination of dust collectors and the series of wet scrubbers. The current level of particulate and sulfur dioxide emissions will be reduced by 75 per cent and 90 per cent respectively, over the existing in-building systems being replaced by the Thermal plant.

For heating purposes, steam goes directly from the boilers into the distribution network. For cooling, steam generated in the boilers is piped at 400 pounds pressure and 600 degrees, to the cooling building which contains two steam turbine driven chillers rated at 14,000 tons of cooling capacity. The condensing turbines on the chillers receive steam from the noncondensing turbines which drive primary pumps.

Two cooling towers reject heat from the refrigeration cycle.

Under City Streets

Steam and 41-degree chilled water are piped under city streets through a four-pipe distribution system which will be 15,000 trench feet in length. The condensed steam and 57-degree chilled water is returned to the district plant in closed recirculatory cycles. This four-pipe distribution system consists of a chilled water supply line, a chilled water return line, a steam feed line and a condensate return line.

Although solid waste is the principal fuel for steam production, each incinerator is equipped with auxiliary gas and oil burners. The auxiliary fuels are deemed necessary by systems engineers for the maintenance of consistent steam pressure in the event of an unusually high moisture content of wet solid waste. In addition, a 125,000 pound per hour standby and supplemental package boiler fired by gas or waste oil is also available to increase the overall plant reliability and operational flexibility during maintenance periods. Engineers estimate average auxiliary fuel usage will be less than ten per cent of the fuel required.

Electricity Generated

In addition to heating and cooling services, Thermal generates electricity for its own use. Also, by utilizing waste oil (primarily from automobile crankcases) for standby reserve, the system relieves a secondary waste problem.

The contemporary buildings and landscaped grounds of the thermal plant are on property which will soon be developed as a scenic riverbank park and garden.

Already Expanding

So successful has the project been so far, that Thermal —a private, not-for-profit organization—is already committed to expansion of the distribution system and the cooling plant. This expansion should be completed by mid-1976. As with the original construction, the expansion will be financed entirely by user fees which will be applied to the retirement of revenue bonds. ■

McDermott: He has to find $8 million to solve the problems of turning trash into power.

CITIES

Nashville's trash crisis

Metropolitan Nashville officials had thought they had an inexpensive solution to the area's landfill, heating, and air pollution problems when they established the Nashville Thermal Transfer Corp. in the early 1970s. Thermal, a nonprofit corporation, was set up to run an incineration plant to burn the city's garbage and to produce steam and chilled water in the process for sale—theoretically at a surplus—to state, municipal, and commercial customers.

But Nashville has now learned that it cannot solve these problems on the cheap. In two years Thermal has run afoul of the Environmental Protection Agency over inadequate pollution-control equipment, lost $3.6 million, and nearly defaulted on its $16.5 million bond issue.Its difficulties have caused its 10 private customers, especially a new Hyatt Regency Hotel, severe financial problems. Nashville's city-county metropolitan government recently had to bail Thermal out by increasing the annual subsidy tenfold to $1.5 million, to be financed by a new $2 a ton dumping fee on garbage. Much of the subsidy will go to guarantee a new bond issue of up to $8 million, the sum Thermal officials reckon is needed to straighten out the project.

Too much pollution. Indeed, in its fiscal year ended last May 31, Thermal was able to operate by burning garbage only 65% of the time, although 80% is considered normal for such plants. Thermal was forced to use its auxiliary boiler fired by fossil fuel part of that time because its two garbage-burning boilers failed to meet environmental air standards. The original pollution-control equipment, wet scrubbers, had previously been used only on coal-burning boilers and was incapable of controlling Thermal's emissions. Last April, Thermal and the EPA signed a compliance order stipulating that Thermal would install more effective electrostatic precipitators by early 1977 at a total cost of $2.4 million. Until then, the order restricts Thermal to running one garbage burner.

Other technical problems at times prevented Thermal from running even one boiler. The tubing on both garbage burners cracked last spring and forced Thermal to operate with its auxiliary equipment from May 1 until the end of June. Deprived of its "free source" of fuel, Thermal paid more than $100,000 for gas during that period. Operating costs were also increased by problems in the cooling and controls systems. As a result, instead of the 20 employees originally envisioned to run the project, Thermal now requires 46.

Users are unhappy because their heating and cooling bills are higher, not lower

At the same time, service lines were not constructed on schedule because of bureaucratic tangles with the Nashville Housing Authority. Consequently, lagging revenues aggravated Thermal's losses. The company had to borrow $2.4 million from banks, while its bond reserve account fell nearly $1 million below the $1.2 million stipulated by the initial bond indenture.

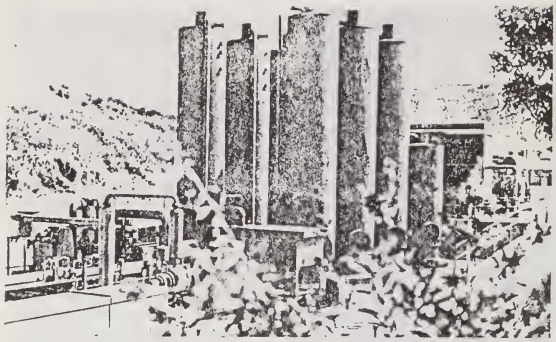
Financially squeezed, Thermal more than doubled its rates in its first year of operation. The new Hyatt, a 24-story structure completed last April, was particularly hard hit. It has no alternative means of heating or air conditioning. Wilson Leary, manager of mechanical and electrical systems for the hotel's general contractor, Ira H. Hardin Co. of Atlanta, says Hyatt might not have signed its 30-year contract with Thermal had it foreseen the rate increases. He says heating and air conditioning the Hyatt with Thermal costs $28,000 a month, while an all-electric system runs about $17,000. Nevertheless, he says Hyatt has no plans to break its contract. And Thermal plans no further rate increases until 1980.

Unlike Hyatt, National Building Corp., owner of an office building served by Thermal, has sued to get out of its contract. The suit says that Thermal made representations of savings by converting to its system but that National's costs increased 291% for steam and 169% for chilled water in four months last year.

Many customers are carefully watching the case, and if it is decided against Thermal, others could follow National. One potential customer, the new Commerce Union Bank building, has presently decided not to do business with Thermal and has instead installed an electric system. The bank's air conditioning system is compatible with Thermal's, so if electric rates increase about 65% to match Thermal's, it could switch.

Some success. But Thermal is not a complete failure. Metro officials say that it is breaking even in buying Thermal's service for three buildings through savings on fuel oil and the fewer maintenance workers it has to employ. Moreover, even operating on one boiler, Thermal consumes 350 to 400 tons of garbage each day, about 25% of Nashville's total. Metro officials also claim the air is cleaner in Nashville because there are 16 fewer individual heating plants in the city. And the state, with 14 buildings on Thermal service, saves not only an estimated $50,000 to $100,000 in operating costs annually but also $2 million to $3 million it would otherwise have to invest in its own plant.

Thermal is now concerned with getting operations in working order. Toward this end, Bernard A. McDermott, 66, a retired manager of environmental control at Ferro Corp., has been brought in as executive vice-president. McDermott has identified 15 critical problems, such as pollution control, burning wet garbage, and boiler-control systems, that must be solved. But McDermott's immediate task is to come up with about $8 million to do the job. The money will come from a new bond issue this spring and possibly from a state loan. ■



MOLECULAR-SIEVE TOWERS at Palos Verdes landfill clean gas for recovery of methane.

Tapping garbage for pipeline gas

In NuFuel process, pretreatment and adsorption obtains 1,000-Btu. methane from 125-ft.-deep wells in landfill

The 1 million cu.ft./day of methane Southern California Gas Co. will be getting from 172 acres of Los Angeles' Palos Verdes landfill is only a drop in the bucket, compared with the 2.5 billion cu.ft./day the company needs. But with today's gas shortage, "we'll take all we can get from alternate sources," said Phillip Ver Planck, the company's manager of supply contract administration, when the methane recovery and processing plant was dedicated last week.

For NRG NuFuel Co., a subsidiary of NRG Technology (Newport Beach, Calif.), Palos Verdes is the first chance to prove out its molecular-sieve processing technique for recovery of methane from landfill. But it is not likely to be the last.

"There are easily 100 very large solid-waste landfills across the U.S. that have a very high probability for commercial quantities of pipeline quality gas," says Frederick C. Rice, NuFuel's marketing manager.

NuFuel and its partner in the Palos Verdes venture, Reserve Oil and Gas Co. (Los Angeles), already have several commitments for methane from landfill developments in Los Angeles, Kansas City, St. Louis, Chicago and Detroit and in Arizona and New Jersey.

Moreover, Ver Planck says Southern California Gas gets about 10 calls a day from prospective methane-from-refuse sources. And with the cost of pipeline gas from coal and synthetic-natural-gas sources zooming to an estimated $4/million Btu., many utilities are likely to turn to landfills to help meet their requirements.

The Palos Verdes landfill is one of the largest (some 4,000 tons/day of garbage) of six operated by the Los Angeles Sanitation District. Only one-fourth of the 172-acre site is being developed for methane recovery. But NuFuel estimates the entire site could eventually provide 5 million cu.ft./day of methane over a 15-20-year period.

Depth of fill varies from 100-150 ft. in the section being developed. It has been completed and closed off for two years. According to NuFuel, the site meets the key criteria for methane recovery—volume and depth of waste, composition of waste and age of fill. (Liquid wastes were included to compensate in part for the lack of rainfall, which normally would have speeded decomposition.)

"We could hardly have chosen a more ideal site," says Rice of the area where NuFuel has been experimenting since 1973 with the technology for which patent applications have been filed.

Going to the Wells: Eight 36-in.-diameter wells, each drilled to a depth of 100-125 ft., are supplying the gas. They are operated under vacuum to prevent gas escaping from the rest of the landfill. The raw gas is dewatered, compressed and condensate is removed. It is sent through a pretreatment system and then a pressure-swing cycle, molecular-sieve-adsorption process that separates the methane from the other gas constituents.

Gas recovered from the landfill is about 55% methane, the remainder is carbon monoxide (up to 44%), water and trace elements. Key to the NuFuel technology is the molecular-sieve purification process.

The molecular sieves—crushed, ground and pelletized zeolites (hydrated metal aluminum silicates)—are packed into 30-ft.-high, 5-ft.-diameter pressurized towers. When the adsorption capacity of the molecular-sieve bed in a tower is exhausted, the vessel is depressurized and evacuated so the adsorbent material can be regenerated.

Each separation unit has three towers. One is onstream while two are being regenerated.

Three vessels are required because contamination builds up during the normal pressure-swing cycle and must be driven off during a thermal-swing cycle. The switch from one cycle to another is automatically controlled.

A design refinement recently added to the process is the closed-cycle pretreatment system. A proprietary filtration medium removes gross contaminants and most of the water that remains after the condensation step. Hydrogen sulfide and trace elements recovered during pretreatment are used as fuel for the heater that regenerates the pretreatment medium.

Palos Verdes has two of the three-vessel swing-cycle units and two pretreatment units for processing 1 million cu.ft./day of methane.

Cost Competitive: NuFuel will not disclose the cost of the Palos Verdes facility. Nor will the company discuss the price Southern California Gas is paying for the pipeline quality methane—except to say that it is "competitive with California and out-of-state natural gas," and cheaper than LNG, SNG and other gas that could be produced from various sources.

Methane from landfill has a broad, but high, price range to shoot at. The going rate for intrastate gas is about $2/million Btus. and pipeline quality gas from coal from the proposed 250-million-cu.ft./day Four Corners project (five coal-burning power plants, where Utah, Arizona, New Mexico and Colorado join) is estimated at $4/million cu.ft.

Some observers question whether production of 1,000-Btu./cu.ft. pipeline methane is worth the effort and expense when 500-Btu. methane could be recovered more easily and used at the site for power generation.

In fact, there already is one such project—Los Angeles' Dept. of Water and Power is generating 200 kw. of electricity from a landfill in Sun Valley by burning some of the gases taken directly from wells drilled into landfill. The gases are not cleaned or separated. And Pacific Gas & Electricity and the city of Mountain View, California, are studying the feasibility of a similar project.

(Excerpted from: Compilation of Papers from Third National Congress: Waste Management Technology and Resource Recovery, co-sponsored by National Solid Wastes Management Association and U.S. Environmental Protection Agency. [Washington?] National Solid Wastes Management Association, 1975.)

METHANE GAS RECOVERY FROM SANITARY LANDFILLS - A PROMISING ENERGY SOURCE

Myron R. Jones
Supervisory Resource Engineer
Pacific Gas & Electric Company

When solid municipal waste is placed in a landfill, the organic portion of the waste slowly decomposes. This decomposition eventually becomes anaerobic, and a gas rich in methane is produced. The composition of a typical landfill gas is given in Table 1.

The production of such landfill gas is by now a well documented fact. What remains to be demonstrated is the sustained rate at which such gas can be withdrawn from a given landfill, and what total volume of gas can be produced per ton of waste in-place. These two factors will determine whether or not methane can be economically recovered from a landfill.

The rate, quantity and composition of gas produced in a landfill will vary from site to site, and will be dependent on a number of parameters including the following:

- Composition of waste.
- Physical state of waste.
- Moisture content.
- Leachate pH.
- Landfill density, permeability or porosity.
- Type of seal and cover.
- Presence of methane producing bacteria and nutrients.

It is probable that a number of other important variables are also involved.

In order to assess the general feasibility of methane from landfill one needs to estimate certain limiting conditions in order to set criteria for a testing program. An upper limit on methane production can be established based on waste carbon content. Table 2 gives a typical analysis of solid municipal refuse. If the gas composition of Table 1 is used, and all the carbon in the waste is assumed converted to methand and CO2, the maximum methane production would be approximately 10,400 scf per ton of waste, or ~5 scf/lb.

TABLE 1

TYPICAL LANDFILL GAS COMPOSITION*

	% Volume
Hydrogen	0.04
Nitrogen	9.52
Oxygen & Argon	2.74
Carbon Dioxide	35.70
Water Vapor	1.50
Methane	50.50
C_{2+}	Trace
	100.00

Higher Heating Value = approximately 512 Btu/scf.

*Source - Preliminary Gas Analysis Mountain View.

TABLE 2

TYPICAL SOLID MUNICIPAL REFUSE COMPOSITION

Combustibles -		61.0 Wt.%
C	46	
H	6.4	
O	38.2	
N	0.9	
S	0.12	
Cl	0.23	
Inerts	8.2	
	100.05	
Moisture		25.0
Magnetic		5.2
Aluminum		0.7
Glass		5.9
Debris		2.2
		100.00

Complete carbon conversion is highly unlikely, since a landfill is certainly not an optimum reactor design for anaerobic decomposition. Furthermore, a portion of the organic or combustible fraction of solid waste is made up of plastic and other non-biodegradable material. Lacking a good theoretical model for landfill gas production, long duration tests are the only reliable way to determine the ultimate methane production per ton of waste. For preliminary site evaluation purposes, we have assumed a carbon conversion of approximately 10% of theoretical, or about 1,000 scf of methane recovered per ton of waste. We think this is a reasonable assumption on which to evaluate the concept.

After estimating the total methane production per ton of refuse, the next important factor is the rate at which it can be produced. Flow tests have been conducted at a number of landfill sites. One long term test conducted by the Los Angeles Department of Water and Power at the Sheldon Arleta Landfill has shown that a gas flow rate of about 1 scf of gas/foot of waste fill depth can be sustained. This test work also indicates that a single well can draw gas from about a 200-foot radius. Thus, knowing the tons in-place in a landfill, its depth and the area of fill, a rough estimate of steady state gas flow rate can be made. Using the above criteria, and with assistance from Easley and Brassy Corp., a preliminary survey of Bay Area Landfills has been completed.

There are 32 existing landfill sites in the greater Bay Area. Five of these sites are Class 3 and thus receive inert, non-decomposible wastes. Another three sites are at present too small to be good prospects for methane production. The remaining 24 sites should have the potential to produce in total approximately 24 MM scf per day of landfill gas, or the gas requirements of 38,000 homes. Extended over the expected life of these sites, this would amount to an equivalent of 8MM barrels of fuel oil. Although this amount of energy is small when compared to Pacific Gas & Electric's requirements, it is certainly worth developing. Another way of looking at methane from landfill is by comparison with a natural gas well. An average California gas well produces about 1MM scf per day of methane, has a life of seven to ten years, is around 5,000 feet deep and costs in the vicinity of $200,000 to drill. Thus, if our assumptions on methane production from landfills are correct, a site with two million tons of waste in-place should be capable of producing about half the methane obtained from a typical natural gas well, with equal or better life expectancy. Although there is a major difference in gas quality, the high costs of drilling natural gas wells should help offset treatment costs.

The economics of methane production from landfill will be greatly influenced by the way in which the gas is utilized. As part of an EPA funded study on methane recovery from landfill, being conducted by the City of Mountain View, California, Pacific Gas & Electric is evaluating the gas utilization modes shown in Table 3.

TABLE 3

UTILIZATION MODES FOR LANDFILL GAS

1. Injection of low Btu gas into existing transmission lines.
2. Sale of low Btu gas to nearby interruptible gas customers.
3. Treatment of gas to produce pipeline quality SNG.
4. On-site power generation using raw landfill gas.
5. On-site conversion of methane in the landfill gas to methanol.
6. On-site conversion of methane in landfill gas to LNG.

Evaluation of these options is still in progress; however, some general comments can be offered. First, because landfill gas production rate and life are uncertain, utilization modes with minimum capital risk are desirable. Thus, either injection of low Btu gas into existing transmission lines, or sale of low Btu gas to nearby interruptible gas customers, by virtue of their low capital costs, would probably be the most attractive, at least for the first few landfill gas recovery projects. On-site power generation may also be promising since gas treating is not required and small scale generating equipment is relatively portable and could be salvaged if a landfill site fails as a sustained methane producer.

It also seems obvious that methanol production from landfill gas is a rather dubious prospect due to the small scale equipment required and the complication of the process which results in high capital and operating costs. Methanol is, however, a premium product and should be considered.

Based on our initial survey of existing Bay Area landfills, it appears that gas from most of the larger sites can be injected into transmission lines or sold to nearby interruptible gas customers. At the remaining landfills, on-site power generation should be feasible. Thus, it seems that expensive gas treating or conversion to methanol or LNG is unnecessary.

It should also be pointed out that gas scrubbing or conversion to methanol or LNG consume energy and thus, the minimum degree of treatment necessary to make the gas usable will maximize energy recovery.

I would like now to briefly touch on the long range possibilities of methane recovery from landfills. As previously mentioned, existing sanitary landfills will in all probability produce only a small fraction of the methane theoretically obtainable. However, the capital and operating costs for landfills, including methane recovery, are quite low when compared to the more sophisticated energy from waste processes such as pyrolysis, incineration, etc.

It seems to me quite conceivable that if the variables controlling anaerobic decomposition of solid waste in a landfill were well understood, optimum conditions could be established and maintained which would result in relatively high yields and production rates of methane. It may be that landfill "processing" of prepared solid waste may prove to be one of the most cost effective methods of obtaining energy from refuse.

It is expected that the EPA-Mountain View study will give some valuable information about this possibility, but additional study into optimizing methane production from both existing and future landfills would seem to be well worthwhile. I realize that landfills are considered rather undesirable and have many negative aspects such as problems with leachate, odors, etc. However, modifications aimed at optimizing methane production could reduce many of these liabilities.

In conclusion I would like to suggest that in view of the rapidly escalating natural gas prices, landfills should be thought of as potential gas wells rather than worthless dumps and that instead of discarding the landfill approach as an old fashioned wasteful disposal method, more research should be funded to optimize landfill gas production to see if the method may not rival other processes for energy recovery from municipal wastes.

High Technology Recycling Mainly Benefits Polluters

*by Neil N. Seldman**

American cities are paying out $6 billion annually for solid waste treatment. These costs will rise sharply in the immediate future as landfill space is virtually exhausted and traditional incineration must now meet new air pollution guidelines.

City officials and environmentalists all acknowledge that municipal garbage must be recycled in order to save tax dollars as well as material and energy resources. From 50 to 85 percent of our garbage consists of recyclable paper, plastic, metal, glass and compostable organic matter. But there is a considerable difference of opinion as to what is the best way to approach recycling. In fact there is a major national battle underway over who should control and profit from recycling the 150 million tons of municipal garbage produced each year.

The battle is between large corporations who have been promoting high technology resource recovery plants and both small businesses and neighborhood-based groups who have been operating profit making, low technology collection/recycling systems.

Most people have been made aware only of the high technology approach. Most recently, a national publicity and lobbying campaign, supported by the corporations responsible for producing most of our waste, has been geared up in response to the rejection of resource recovery systems by two major cities, Portland, Oregon and Washington, D.C. (In addition, Seattle and Minnesota Pollution Control Agencies have been warned against investing in similar systems at this time by independent consulting firms.) As a result of the campaign, the public sees only positive descriptions of these systems in prestigious magazines and newspapers. Articles are complete with quotes from professional scientists, and leave the impression that the solution to our dilemma is near at hand. Unfortunately, this is not the case. There is a much larger story behind the political economy of garbage in America.

High technology resource recovery plants are supposed to mechanically separate out the recyclable fraction of the waste stream and burn the remaining portion as a fuel supplement, either to produce steam for electricity or to produce oil for future combustion. There are several types of resource recovery plants. But they have yet to work, although theoretically they are feasible. Mechanical separation, combustion and air pollution control equipment have failed to work in plants in St. Louis, Baltimore and Nashville. The result has been higher costs, delays and the need for even more sophisticated technology which planners hope will correct the problems. In Nashville, the Thermal Transfer Corporation announced that unless $8 million more was forthcoming, bondholders of the original $16 million invested would lose out.

The huge capital investment and high operating costs of the systems require that large amounts of garbage be available to make the investment justifiable. Two cities, New Orleans and Hempstead, N.Y., were forced to sign contracts with penalty clauses should they enact legislation that would reduce the flow of the waste stream to proposed plants. No one is suing over these clauses as yet. Other cities have found that systems will have cost from $25 to $40 million for plants with daily capacities of from just 650 to 1,000 tons when all the bonds for raising capital are paid.

After a city builds a high technology plant they will be faced with garbage treatment costs that are not significantly reduced. This is so because these plants deal only with disposal costs, and, though, they reduce these costs, disposal accounts generally for only one third the total cost. Collection and clean-up account for the rest. Thus in St. Louis where an 8,000 ton plant costing $80 million is being built, total solid waste treatment will cost $50 per ton after the new system is on line, exactly what the city is currently paying.

Large corporations rarely assume the risk of investing in high technology plants. Almost all of the plants being built, or planned, are using public funds or are guaranteed by state bonding authorities. As a result, plants are being built and proposed even though markets for the fuel supplement are not yet secured, where the sale of this refuse-derived-fuel is to be the primary source of revenue from the system.

Even if the high technology systems prove workable they may not be the best available alternative for garbage recycling. As the value of recyclable materials increases in the face of energy and materials shortages and ecological concerns, more and more items will be pulled out of the waste stream before they get to the resource recovery behemoths. This process is already happening. If paper is burned in a resource recovery plant it is worth from $5 to $8 per ton based on its BTU value. But if recycled as fiber it

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ENVIRONMENT ACTION BULLETIN is published bi-weekly by Rodale Press, Inc., Emmaus, Pa. 18049. Subscription rates: 6 months, $5.00. One year, $10.00. Inquiries about bulk rate subscriptions welcome. Second class postage paid at Emmaus, Pa. Printed in the United States of America. Copyright© 1976 by Rodale Press, Inc.

may be worth from $10 to $200 per ton. Community groups, universities, office buildings, supermarkets and factories are now reselling their paper.

In the past year comprehensive collection/recycling operations have sprung up in 21 cities across the country. They collect household and business garbage that has been pre-sorted according to categories. It takes just 16 minutes per household per week to adequately prepare the materials. Materials are collected in small vehicles, which replace the $35,000 compaction trucks, and delivered to either centrally located bins or directly to processing plants. These plants, which have been operating for three years and cost approximately $100,000 per 300-ton daily capacity, simply crush materials and send it along conveyors to appropriate rail cars or trucks for shipment to commercial markets. Some facilities are equipped with laser beams for color sorting of glass, and small aluminum smelters which allow the operation to get up to 50 percent more than the current $300 per ton price for recycled aluminum.

These collection/recycling operations are profit-making and will become more efficient as they gain experience. Technical, routing, service and equipment information is shared through a newsletter, *The Wastebin,* P.O. Box 14012, Portland, Oregon 97214, and costing $1 for a year's subscription. The technology poses no threat to the environment and actually saves us the cost of mining basic materials. Recycling will also greatly benefit from changes in the current practice of subsidizing virgin material production. These subsidies occur in lower shipping rates for virgin goods, favorable lease arrangements for public land, depletion allowances and other tax credits, and exemption from environmental and clean-up costs. When these are removed, virgin materials will cost more and thereby will support the recycling market which is now characterized by wild fluctuations.

The decentralized approach to garbage recycling allows for great flexibility. It is consistent with source reduction techniques and requires little capital investment. Cities facing the garbage dilemma should give highest priority to this approach to recycling.

Although we seldom think much about our garbage, much less about the most efficient way to recycle it, the outcome of the current battle over garbage has economic and philosophic implications. Will Americans closely scrutinize their food, energy, production and waste systems, and actively choose those that are compatible with their best interests?

What You Can Do in Your Town

You can get information on big technology resource recovery systems pushed by big corporations, and on soft technology small-scale systems by writing to Penny Hansen, Office of Solid Waste Management, Environmental Protection Agency, Washington, D.C.

Then find out what your town plans to do about its solid waste load by attending a city council meeting and asking questions. If the city or town plans to go the big technology route, ask to see what information they are using as the basis for the decision.

You can then present information at a subsequent town meeting on plans such as Oregon's ORE plan, Bangor, Maine's sludge composting project, etc., comparing cost and benefits by using information obtained from Ms. Hansen, from Neil Seldman, from *The Wastebin* (the address is included in Seldman's article) and by asking for specific information from *Compost Science* magazine, Emmaus, Pa. 18049.

V. INSTITUTIONAL IMPEDIMENTS AND FINANCING

(Excerpted from: U.S. Environmental Protection Agency, Second Report to Congress: Resource Recovery and Source Reduction. Washington: U.S. Government Printing Office, 1974.)

FEDERAL PROCUREMENT OF PRODUCTS CONTAINING RECYCLED MATERIALS

The Federal procurement process can play an important role in bringing about increased utilization of secondary material. In the past, Federal purchasing regulations, not unlike such practices in the private sector, have been discriminatory in requiring the use of virgin materials when technically equivalent secondary materials were available.

To evaluate the prospects for encouraging resource recovery through Government purchase of products containing recycled material, several issues will be discussed: (1) the potential for Federal procurement to develop market demand for recovered resources, (2) previous attempts to incorporate recycled materials into federally purchased products and opportunities to expand these practices, (3) the barriers to increased Federal procurement of waste-based products and the problems of administering and implementing such programs.

Federal Procurement as a Demand Creation Mechanism

Of the $66 billion in direct Federal procurement in 1970, $53.4 billion was defense and $12.6 billion was nondefense related (Table 17). These expenditures represent 3.12 and 0.74 percent of the gross domestic output, respectively.* Table 18 presents the procurement expenditures for various commodities as a percent of the domestic output of that commodity.

TABLE 17
DIRECT FEDERAL PROCUREMENT EXPENDITURES, 1970*

Type of expenditure	Expenditure	
	Billions of dollars	Percent of gross domestic output†
Defense	53.4	3.12
Nondefense	12.6	.74
Total	66.0	3.86

*Source: Arthur D. Little, Inc. Study of Federal purchasing to reduce solid waste. U.S. Environmental Protection Agency Contract No. 68-03-0047, [1973]. (Ongoing study.)

†$1.71 trillion in 1970.

Federal expenditures that represent a large percent of the domestic market for a commodity fall mainly in defense-related areas: ordnance, 75 percent; explosives, 48 percent; aircraft, 41 percent; communication equipment, 31 percent; ships, trains, trailers, and cycles, 19 percent; nonferrous ore mining, 19 percent; and industrial organic chemicals, 11 percent. Many of these commodities represent special-purpose equipment for which secondary material utilization would not be suitable. In addition, it would be very difficult to specify the secondary material content of a multicomponent complex product such as an airplane or motor vehicle.

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TABLE 18

DIRECT FEDERAL PROCUREMENT EXPENDITURES AS A PERCENT OF DOMESTIC OUTPUT OF THAT COMMODITY, 1970*

Commodity	Defense	Nondefense†	Total
Ordnance	55.63	19.39	75.02
Explosives	45.52	2.32	47.84
Aircraft and parts	35.26	5.26	40.52
Communication equipment	27.47	3.96	31.43
Ships, trains, trailers, and cycles	14.84	4.06	18.90
Nonferrous ore mining	18.10	.51	18.61
Industrial organic chemicals	10.69	.52	11.21
Instruments and clocks	7.04	2.28	9.32
Electronic components	7.65	1.17	8.82
Office supplies	4.28	3.57	7.85
Engines and turbines	5.69	.99	6.68
Maintenance construction	3.86	2.69	6.55
Industrial gases	3.37	3.06	6.43
Batteries and X-ray and engineering electronic equipment	5.31	.82	6.13
Office computing and accounting machines	4.36	1.67	6.03
Electric apparatus and motors	4.88	.91	5.79
Optical and photographic equipment	3.43	1.96	5.39
General industrial machines and equipment	4.72	.41	5.13
Materials and handling equipment	4.54	.50	5.04
Industrial inorganic chemicals	3.76	–	3.76
Biological products	1.03	2.72	3.75
Petroleum refining	3.35	.31	3.66
Gum and wood chemicals	.03	3.58	3.61
Miscellaneous rubber products	3.35	.17	3.52
Construction and mining machinery and equipment	2.74	.18	2.92
Truck trailers	2.40	–	2.40
Household textiles and upholstery	1.96	.23	2.19
Machine shops and miscellaneous machinery	2.00	.06	2.06
Office furniture	.67	1.26	1.93
Pharmaceutical preparations	.98	.88	1.86
Commercial printing	2.69	(-.85)	1.84
Motor vehicles and parts	1.57	.16	1.73
Coal mining	1.42	.24	1.66
Metalworking machinery and equipment	1.22	.40	1.62
Chemical preparations	1.40	.10	1.50
Tire and inner tubes	1.42	.08	1.50
Cellulosic man-made fibers	1.38	–	1.38
Dairy products	.69	.67	1.36
Agricultural, forestry, and fishery products	1.31	.01	1.32
Polishes and sanitation goods	.87	.40	1.27
Service industry machines	1.08	.09	1.17
Fertilizers	.03	1.09	1.12
Fiber cans	1.12	–	1.12
Wooden containers	1.08	.01	1.09
Grain mill products	.08	.87	.95
Inorganic pigments	.92	–	.92
Iron and ferro alloy ore mining	1.70	(-.79)	.91
Sanitary paper products	.34	.56	.90
Agricultural chemicals	.34	.39	.73
Primary and secondary aluminum	.63	.03	.66
Wood preserving and miscellaneous products	.42	.23	.65
Miscellaneous plastic products	.53	.09	.62
Structural metal products	.51	.09	.60
Medicinals and botanicals	.58	–	.58
Noncellulosic organic fibers	.58	–	.58
Stampings, screws, machine products, and bolts	.44	.13	.57
Meat packing	.42	.14	.56
Hardware, plating, wire products, and valves	.38	.17	.55
Special industrial machinery	.28	.27	.55
Coated and converted paper	.32	.21	.53
Papermill products	.13	.40	.53

TABLE 18

DIRECT FEDERAL PROCUREMENT EXPENDITURES AS A PERCENT OF DOMESTIC OUTPUT OF THAT COMMODITY, 1970—*Concluded*

Commodity	Defense	Nondefense†	Total
Plastics materials and resins	.51	–	.51
Soap and other detergents	.42	.09	.51
Household furniture	.23	.27	.50
Glass and glass products	.28	.21	.49
Rubber footwear	.46	–	.46
Apparel	.26	.17	.43
Farm machinery and equipment	.36	.04	.40
Electric lighting and wiring equipment	.37	.02	.39
Primary and secondary copper	.08	.30	.38
Cyclic intermediates and crudes	.35	–	.35
Miscellaneous food products	.05	.30	.35
Cardboard boxes	.23	.09	.32
Rugs, tire cord, and miscellaneous textiles	.21	.11	.32
Book printing and publishing	1.19	(-.88)	.31
Synthetic rubber	.31	–	.31
Fabrics and yarn	.29	–	.29
Metal containers	.29	–	.29
Canned and frozen goods	.17	.10	.27
Stone and clay products	.34	(-.07)	.27
Primary and secondary iron and steel	.20	.01	.21
Bakery products	.13	.07	.20
Household appliances	.16	.04	.20
Corrugated and solid fiber boxes	.12	.05	.17
Shoes and other leather products	.11	.02	.13
Sugar	.09	.04	.13
Beverages	.09	.03	.12
Paints and allied products	.08	.04	.12
Paperboard mill products	.09	.03	.12
Stone and clay mining and quarrying	.42	(-.31)	.11
Miscellaneous manufactured products	.12	(-.02)	.10
Leather tanning	.06	.02	.08
Chemical and fertilizer mineral mining	.05	.01	.06
Confectionery and related products	.03	.02	.05
Livestock	–	.02	.02
Newspapers	.01	.01	.02
Periodicals	.01	–	.01
Sawmill and planning mill products	–	–	Negligible
Toilet preparations	–	–	–

*Source: Arthur D. Little, Inc. Study of Federal purchasing to reduce solid waste. U.S. Environmental Protection Agency Contract No. 68-03-0047, [1973]. (Ongoing study.)

†Negative numbers represent Federal subsidy.

As may be seen in Table 18, for many commodities Federal expenditures are less than 2 percent of domestic output. Included in this category are commodities that have a significant potential for secondary material content: paper and paperboard products, iron and steel, nonferrous metals, glass products, plastics, and rubber products. It is apparent that Federal purchases do not dominate the market for these commodities. Although the Federal Government is a large single consumer, Federal expenditures only represent a small fraction of combined industrial, commercial, and personal expenditures in these areas.

The direct market creation effect of Federal purchasing of waste-based products would probably be small. However, Federal procurement specifications are widely circulated and duplicated by State and local governments and some industries. If the results of Government experience with secondary material were publicized through a technical assist-

ance and information program, more widespread utilization of secondary material in other sectors could result.

In Executive Order 11514, March 1970, the President directed Federal agencies to "initiate measures needed to direct their policies, plans, and programs so as to meet national environmental goals." This charge was reiterated by the President in the 1971 environmental message, and the General Services Administration was directed to institute a program requiring a percent of recycled fibers in purchased paper products. Other agencies have also attempted to utilize various secondary materials.

General Services Administration Recycled Paper Procurement Programs

In this program, paper procurement specifications were adjusted to require various percents of recycled fiber. The specifications are written in two parts. The first part specifies the required percent of recycled fiber from post-consumer waste sources (e.g., old corrugated boxes, newspapers, magazines, mixed wastepapers, and all fibrous materials recycled from municipal solid waste). The second part of the specification indicates the percent of secondary fiber that may be derived from converting and fabrication wastes (e.g., envelope cuttings, paper trimmings, rejected paperstock, and other papermill and textile mill wastes).

The required percents are set by taking into consideration technical performance requirements, availability of supply, and product price. No special consideration is given to suppliers who can exceed the required percents. Suppliers are required to certify that the recycled fiber content of paper items sold to the Government conform to these specifications.

The General Services Administration utilizes 144 different paper specifications. In fiscal 1972 it purchased $88 million in paper products. To date 77 specifications, representing $56.6 million in purchases, have been changed to require some percent of reclaimed fibers. Table 19 summarizes the purchases in various paper commodity areas along with the ranges of post-consumer waste and other recycled fibers.

Department of the Army Retread Tire Program

The Department of the Army has exercised a program of retreading automobile and truck tires since World War II. This program was intensified in 1970 after issuance of Executive Order 11514. In addition to reducing solid waste, retreading has substantial cost advantages. For example, a 50-percent cost saving can be achieved by retreading a tire rather than purchasing a new replacement. The Army's present goal is to retread 75 percent of the tires it replaces. Table 20 shows that progress toward the goal has been significant.

This practice could also be extended to other agencies such as the Postal Service and the General Services Administration, which also maintain motor vehicle fleets, but tire safety and performance considerations are major issues preventing this more widespread use of retreads.

TABLE 19

SUMMARY OF RECYCLED FIBERS REQUIRED IN GENERAL SERVICES ADMINISTRATION PROCUREMENTS, FISCAL 1972*

Commodity	Purchases (millions of dollars)	Reclaimed fibers (percent)	Post-consumer waste fibers (percent)
Building materials	0.2	40	30
Office supplies	17.5	15-100	0-75
Packaging	19.5	3-100	0-90
Tissue	19.4	20-95	5-35
Total	56.6		

*Source: Data provided by the General Services Administration.

TABLE 20

SUMMARY OF RETREADING PROGRAMS, DEPARTMENT OF THE ARMY*

Period	Total tires replaced	Retreaded tires	Retreads (percent)
July to December 1971	278,108	162,195	58
January to June 1972	233,798	160,248	68
July to December 1972	227,785	160,743	71

*Source: Data provided by Staff for Logistics, Maintenance Engineering Branch, Department of the Army.

Joint Committee on Printing Use of Secondary Fibers in Printing and Publishing Papers

The Joint Committee on Printing is responsible for specifications for all stationery, printing, and publishing paper used by the Federal Government. In December 1972 EPA was granted permission by the

Joint Committee on Printing to use recycled paper for internal bulletins, newsletters, and press releases on an experimental basis. No minimum percent of secondary fibers is specified, but the suppliers are required to certify recycled fiber content. EPA printing departments and the Government Printing Office are evaluating this program, which if successful may be extended to other agencies.

Barriers to Expanded Use of Recycled Materials in Federal Purchases

It is apparent that although there have been major inroads in a few areas, such as recycled paper use and tire retreading, on the whole there has not been widespread utilization of secondary materials in products purchased by the Federal Government. Uncertainty of supply, budgetary constraints, and administrative and implementation problems appear to be the major barriers to more extensive recycled material procurement.

The basic mission of the Federal supply services is to provide other Government agencies with the materials and products that they need, when they are needed, at the lowest possible cost. Use of recycled materials introduces technical and economic risk into this process. There are two aspects to the uncertainty of supply: uncertainty regarding the technical performance of products supplied and uncertainty as to the availability of secondary materials. Expanded tire retreading is inhibited by the former aspect and the General Services Administration recycled paper program was constrained by the latter (whenever a possibility of shortage occurred, the recycled fiber requirement was reduced or eliminated).

Budgetary constraints arise from the fact that for many products it is more expensive to use secondary than virgin material. This is especially true for paper. The cost difference is very significant for high-grade paper such as printing paper and stationery; for lower grade paperboards this cost constraint is not as severe. In the General Services Administration paper program, higher prices were not offered for products containing higher percents of recycled fiber. Furthermore, if the price of a recycled product was found to be unreasonably high relative to a virgin product counterpart, the recycling percents were reduced.

Administrative and implementation problems arise because of the need to revise procurement specifications and procedures and monitor and certify recycled material levels.

Conclusions and Recommendations

Federal procurement in itself will not create a significant new market demand for recycled material but can serve a valuable function in helping to establish the technical and economic factors of recycled material use. Recycling considerations introduce higher prices for purchased goods, uncertainty of supply, and an additional new administrative burden into the procurement process.

Therefore it is recommended that EPA, in conjunction with the supply agencies, develop guidelines for the inclusion of secondary material to the maximum extent practicable in products purchased by the Federal Government. These guidelines should consider level of recycled material content, costs, and monitoring procedures.

In developing these guidelines, EPA in conjunction with the procurement agencies should perform the studies necessary to establish (1) criteria for selecting materials and products to be considered in this program, (2) technical and economic limitation of recycled material use in various products, (3) present and future sources of secondary material supply.

TAX BENEFITS FOR VIRGIN MATERIALS

Various provisions of the Federal tax code result in benefits to the virgin material production sectors of the economy as opposed to the secondary material sector. In this section those tax benefits available to the virgin mineral and paper industries are identified and defined, preliminary quantitative estimates of the dollar size of the benefits are provided, and the purpose and rationale for these special tax provisions are analyzed. The objective of this discussion is to attempt to evaluate the degree to which these tax provisions influence the use of virgin rather than secondary materials.

The tax code provides a number of ways to deduct the cost of doing business from sales. All such provisions (such as accelerated depreciation, investment tax credits, and deduction of State and local taxes) that apply equally to both the virgin and secondary material industries are not considered in this report. Only those tax provisions that are available only to virgin material industries and, in effect, subsidize virgin material use, are analyzed.

Definitions of Tax Benefits for the Virgin Material Industries

Depletion Allowance. The depletion allowance is a tax deduction based on the depletion of a mineral deposit. There are two methods for calculating depletion allowance: the percentage method and the cost method. Each year the method providing the larger deduction is used. As will be explained, the tax benefit is the excess of the percentage depletion allowance above the cost depletion allowance.

Cost depletion provides for the recovery of the investment required to exploit a mineral deposit. If 10 percent of a mineral deposit is extracted in 1 year, 10 percent of the costs of acquiring that deposit can be deducted from gross income. This type of depletion is not considered to be a special benefit. It is analogous to the deduction of other costs of doing business such as the depreciation of the plant and equipment. The cost depletion allowance takes into account the exhaustion of a stock of capital, just as depreciation accounts for the predictable replacement of capital because of wear and tear and obsolescence.

Unlike cost depletion, the percentage depletion allowance bears no relationship to the cost of acquisition of a property. In fact, using the percentage depletion formula, the cumulative annual deduction from income can eventually exceed the original cost. The percentage depletion allowance is calculated by taking a fixed percentage (e.g., 22 percent for petroleum) of the gross income generated by the property. The percentage depletion allowance is limited by the fact that it cannot exceed 50 percent of the taxable income in any year. Even so, the percentage depletion allowance is in many cases much greater than the cost depletion allowance. Therefore, the percentage depletion allowance provides a tax benefit for the virgin mineral industries that has no analogous counterpart in other areas of industry or commerce. The actual benefit provided by the percentage depletion allowance is the amount of the deduction taken by the mineral industries above that allowed by the cost depletion method.

Expensing of Capital Expenditures. For most capital assets, costs required to develop, improve, or otherwise increase the value of the asset cannot be deducted from income in the year that they are incurred but must be capitalized instead (i.e., added to the cost of the asset and recovered over time through depreciation or depletion). However, the mineral industries are allowed to deduct from current income exploration and development costs that occur before a mine reaches the production stage. The timber industry is allowed to deduct from current income costs for pruning, thinning, and shaping of trees as well as disease control expenditures. The effect of this provision is to advance the timing of recovery of these costs and provide a benefit equivalent to the time value of the funds recovered.

Capital Gains Treatment. For most corporations, property held and then sold in the ordinary course of doing business is subject to ordinary income taxes at the time of sale at the maximum rate of 48 percent. But the income received from the sale of timber is subject instead to capital gains tax treatment. This special allowance for the sale of timber reduces tax payments from the ordinary 48 percent rate to the 30 percent capital gains tax rate.

In the case of coal and domestic iron ore, if after disposing of a commodity an economic interest is retained and royalties are received, such royalties are also eligible for capital gains treatment.

Foreign Tax Allowances. There are several special tax provisions available to U.S. firms with foreign-based operations. Because many U.S. firms in the virgin material business own foreign holdings, these provisions provide a benefit not available to domestic secondary material firms. Four foreign tax benefits have been identified: the foreign tax credit, the exclusion for less-developed country corporations, the exclusion for controlled foreign subsidiaries, and the Western Hemisphere trade corporation deduction.

Foreign Tax Credit. Firms operating outside the United States can deduct foreign taxes directly from their U.S. tax liability. This differs from treatment for other taxes (State and local), which are deducted from gross income. The tax credit provision results in a tax deduction twice as large as that which would occur if foreign taxes were deducted from gross income (for firms in the 48-percent tax bracket). The foreign tax credit is available to U.S. timber and mining firms operating in foreign nations.

Exclusion for Less-Developed Country Corporations. For virgin material firms operating in countries defined by the President as "less developed,"

there is an alternative method allowed for determining the amount of foreign tax credits available to offset U.S. taxes that increases the value of the tax credit to the U.S. firm.

Exclusion for Controlled Foreign Subsidiaries. For certain firms that do not repatriate foreign earnings, a deferral of U.S. taxes is allowed.

Western Hemisphere Trade Corporation. For firms operating within the Western Hemisphere, there is a method of calculating U.S. tax owed that reduces the taxes payable by about one-third.

Quantitative Estimates of Tax Benefits

An estimate of the magnitude of the tax payments saved by the virgin material industries because of special tax provisions was made using tax data available from various public sources. The analysis was restricted to virgin materials which compete with material that could be recycled from post-consumer solid waste. An estimate of the tax benefits was made for the following virgin materials: timber (as virgin wood pulp could be displaced by post-consumer wastepaper); oil, gas, and coal (as the use of these fuels could be displaced by energy recovery from post-consumer solid waste); iron ore (which could be displaced by steel from obsolete automobiles or metal cans); primary aluminum (which could be displaced by aluminum from discarded beverage containers and other packaging); and glass sand (which could be displaced by post-consumer cullet).

This analysis was limited by the way in which available public tax data are collected and organized. Data are normally collected by corporation and aggregated by industry. However, for purposes of this analysis it was necessary to develop estimates on a material by material basis. As an example of the problems encountered, it was found that only one-fifth of the depletion allowance statistics are reported as accruing to the mining and timber industries; the remaining four-fifths are reported as accruing to other industries in the economy. Because these tax provisions are only applicable to the mineral and timber industries, it is obvious that many firms performing mining and forestry activities are classified in the tax statistics as being predominantly involved in other production areas. Therefore, various assumptions had to be made to estimate the distribution of the aggregated tax benefits across the individual material areas.

Because of the assumptions necessary in this analysis, the following results should be viewed only as preliminary order-of-magnitude estimates. A more thorough analysis is currently underway using unpublished tax data obtained from industrial sources.[v]

The results shown in Tables 21 to 29 indicate that the capital gains treatment in the timber industry and the percentage depletion allowance in the mineral industries are the most important tax benefits.

The results for timber show an average combined benefit of $0.90 per ton of paper (Table 21). No estimate was made for the additional tax savings due to the expensing of certain capital items because data were not available.

TABLE 21

ESTIMATES OF TAX BENEFITS FOR PAPER* PRODUCTION FROM VIRGIN MATERIALS, 1970

Type	Value for timber (millions of dollars)	Value for paper	
		Unit (dollars/ton)	Total (millions of dollars)
Capital gains treatment	†130.0	0.836	35.10
Foreign tax credit	‡9.8	0.063	2.65
Total	139.8	.899	37.75

*27 percent of all wood goes to paper production; 42 million tons of paper were produced from wood pulp in 1970.

†U.S. Congress. Joint Economic Committee. The economics of Federal subsidy programs. Part 1. General study papers. Washington, U.S. Government Printing Office, May 8, 1972. p.76.

‡EPA analysis of data from Internal Revenue Service. Statistics of income, 1970. Corporation income tax returns. Washington, U.S. Government Printing Office, 1973.

The combined savings for petroleum, $0.35 per barrel, and natural gas, $0.022 per 1,000 cubic feet, are shown in Table 22. In both cases the depletion allowance is of primary importance; the foreign tax credit is the next most important.

The results for iron ore, coal, bauxite, and sand are shown in Tables 23 to 26. Aluminum, mined as bauxite, receives a substantial foreign tax credit

TABLE 22
ESTIMATES OF TAX BENEFITS FOR PETROLEUM AND NATURAL GAS, 1970

Type	Value (millions of dollars)
Depletion allowance*	1,063
Foreign tax credit*	500
Intangible expenses†	184
Exclusion for controlled foreign subsidiaries†	36
Exclusion for less-developed country corporations†	12
Western Hemisphere trade corporation deduction†	5
Total	‡1,800

*EPA analysis of data from Internal Revenue Service. Statistics of Income, 1970. Corporation income tax returns. Washington, U.S. Government Printing Office, 1973.

†EPA analysis of data from U.S. Congress. Joint Economic Committee. The economics of Federal subsidy programs. Part I. General study papers. Washington, U.S. Government Printing Office, May 8, 1972. p.46.

‡For the petroleum industry the benefit is $0.35 per barrel, for a total of $1,350 million; and for the natural gas industry the benefit is $0.22 per 1,000 cubic feet, for a total of $450 million. The total benefit was apportioned by the quantity and value of the commodity at the wellhead: petroleum, 75 percent; natural gas, 25 percent. U.S. Bureau of Mines. 1969 Minerals yearbook. v.1. Washington, U.S. Government Printing Office, 1970.

TABLE 23
ESTIMATES OF TAX BENEFITS FOR IRON ORE, 1970

Type	Unit value* (dollars/ton)	Total value (millions of dollars)
Depletion allowance†	0.364	47.00
Foreign tax credit†	.229	29.60
Exploration and development expensing‡	.107	13.80
Exclusion for controlled foreign subsidiaries‡	.016	2.11
Capital gains treatment‡	.016	2.00
Western Hemisphere trade corporation deduction‡	.011	1.43
Exclusion for less-developed country corporations‡	.005	.70
Total	.748	96.64

*U.S. Bureau of Mines. 1969 Minerals yearbook. v.1. Washington, U.S. Government Printing Office, 1970.

†EPA analysis of data from Internal Revenue Service. Statistics of Income, 1970. Corporation income tax returns. Washington, U.S. Government Printing Office, 1973.

‡EPA analysis of data from U.S. Congress. Joint Economic Committee. The economics of Federal subsidy programs. Part 1. General study papers. Washington, U.S. Government Printing Office, May 8, 1972. p.46.

TABLE 24
ESTIMATES OF TAX BENEFITS FOR COAL, 1970

Type	Unit value* (dollars/ton)	Total value (millions of dollars)
Depletion allowance†	0.072	41.00
Exploration and development expensing‡	.053	30.20
Foreign tax credit†	.011	6.00
Capital gains treatment‡	.005	3.00
Exclusion of controlled foreign subsidiaries‡	.0008	0.43
Exclusion for less-developed country corporations‡	.0002	0.14
Total	.142	80.77

*U.S. Bureau of Mines. 1969 Minerals yearbook. v.1. Washington, U.S. Government Printing Office, 1970.

†EPA analysis of data from Internal Revenue Service. Statistics of income, 1970. Corporation income tax returns. Washington, U.S. Government Printing Office, 1973.

‡EPA analysis of data from U.S. Congress. Joint Economic Committee. The economics of Federal subsidy programs. Part 1. General study papers. Washington, U.S. Government Printing Office, May 8, 1972. p.46.

because most of the raw material is produced outside the United States. The results for all commodities are summarized in Table 27.

The maximum impact of virgin tax benefits on material prices is shown in Table 28. This price effect is shown related to virgin raw material prices and to the prices of processed materials. At the raw material stage this benefit is equivalent to between 6 and 26 percent of the selling price. At the processed material stage the maximum price effect is equivalent to between 1 and 15 percent of the price.

Table 29 shows a comparison of the tax benefits to the difference in cost of using virgin versus secondary materials. This cost differential is taken at a point in production where virgin and secondary materials are equivalent inputs to the production process. For the cases shown in Table 29, use of virgin materials always resulted in a lower cost than use of secondary materials. As the data indicate in most cases, the tax benefits for virgin materials represent a significant fraction of the cost differential.

TABLE 25
ESTIMATES OF TAX BENEFITS FOR BAUXITE (USED FOR ALUMINUM), 1970

Type	Unit value* (dollars/ton)	Total value (millions of dollars)
Foreign tax credit†	0.671	9.40
Depletion allowance†	.550	7.70
Exploration and development expensing‡	.164	2.30
Exclusion for controlled foreign subsidiaries‡	.049	.68
Western Hemisphere trade corporation deduction‡	.046	.65
Exclusion for less-developed country corporations‡	.016	.23
Total	1.496	20.96

*U.S. Bureau of Mines. 1969 Minerals yearbook. v.1. Washington, U.S. Government Printing Office, 1970.
†EPA analysis of data from Internal Revenue Service. Statistics of income, 1970. Corporation income tax returns. Washington, U.S. Government Printing Office, 1973.
‡EPA analysis of data from U.S. Congress. Joint Economic Committee. The economics of Federal subsidy programs. Part 1. General study papers. Washington, U.S. Government Printing Office, May 8, 1972. p.46.

TABLE 26
ESTIMATES OF TAX BENEFITS FOR SAND (USED FOR GLASS), 1970

Type	Unit value* (dollars/ton)	Total value (millions of dollars)
Depletion allowance†	0.082	0.86
Total	.082	.86

*U.S. Bureau of Mines. 1969 Minerals yearbook. v.1. Washington, U.S. Government Printing Office, 1970.
†EPA analysis based on Federal tax code regulations.

Removal of these tax provisions for virgin materials would not necessarily result in an increase in virgin material prices to the maximum extent indicated in Tables 28 and 29. In fact, it is very difficult to estimate what the actual price effect might be. Furthermore, it is even more difficult to estimate the change in virgin or secondary material consumption that would result from a price change. Several of the complications involved are as follows:

(1) The tax benefit is usually not only reflected in lower prices but could also result in higher profits to the recipient firms. Therefore, removal of the benefits would be partially translated into decreased profits rather than increased material prices. In addition, reduction or removal of the benefits may induce firms to change land holdings; modify arrangements with foreign or domestic subsidiaries; and change reserve holdings, which could reduce the impact on prices or profits.

TABLE 27
SUMMARY OF ESTIMATES OF TAX BENEFITS, 1970

Product	Unit value	Total value (millions of dollars)
Paper	$0.899 per ton	37.75
Petroleum	$0.350 per barrel	1,350.00
Natural gas	$0.022 per 1,000 ft³	450.00
Iron ore	$0.748 per ton	96.64
Coal	$0.142 per ton	80.59
Bauxite (used for aluminum)	$1.496 per ton	20.96
Sand (used for glass)	$0.082 per ton	.86

(2) Removal or adjustment of any one tax provision could lead to increased use of other provisions, with the net impact being diminished. For example, if the percentage depletion allowance were decreased, mineral companies could shift to increased use of capital gains treatment or to cost depletion.

(3) Many firms supplying virgin materials are integrated through the basic production industries. In many cases the material value on which the percentage depletion allowance is calculated is not the value at the mine mouth but the value further along in processing. For integrated firms there is no market price to determine this value and an internal transfer price is employed instead. The questions of where in the process the value of the material is estimated and what internal transfer price is employed are of critical importance in determining the price effect of the percentage depletion allowance for any industry.

(4) Material costs in many instances are only a fraction of the price of a final product. In many cases fluctuations in material and product prices could be greater than the value of the tax benefits. These factors would tend to attenuate the price impact of subsidy removal or reduction.

(5) To calculate the change in consumption of virgin and secondary materials that would occur if the

TABLE 28

COMPARISON OF VIRGIN MATERIAL TAX BENEFITS AND PRICES

(1) Product	(2) Tax saving per unit of production	(3) Maximum material price effect of tax saving*	(4) Raw material price (1969-70)	(5) (3) ÷ (4)	(6) Processed material price† (1969-70)	(7) (3) ÷ (6)
Timber (used for paper)	$0.899 per ton	$1.80 per ton	$9.00 per ton stumpage	0.20	$130.00 per ton dry pulp‡	0.01
Petroleum	$0.350 per barrel	$0.70 per barrel	$3.90 per barrel crude oil at the wellhead	.23	$4.62 per barrel, No. 2 fuel oil§	.15
Natural gas	$0.022 per 1,000 ft^3	$0.044 per 1,000 ft^3	$0.167 per 1,000 ft^3 gas at the wellhead	.26	$0.551 per 1,000 ft^3, delivered to consumer§	.08
Bauxite (used for aluminum)	$1.496 per ton	$3.00 per ton	$14.00 per ton bauxite	.21	$544.00 per ton aluminum¶	.04
Sand (used for glass)	$0.082 per ton	$0.15 per ton	$2.38 per ton at quarry	.07	$30.00 per ton molten glass**	.01
Iron ore	$0.748 per ton	$1.50 per ton	$10.84 per ton at mine	.14	$41.00 per ton molten pig iron††	.06
Coal	$0.142 per ton	$0.28 per ton	$5.00 per ton at mine	.06		

*Assuming entire saving is reflected in material price and firm is in the 48-percent income tax bracket.

†Most probable point of competition between virgin and secondary materials.

‡The demand and price of timber 1971-1972. *Official Board Markets*, 1970.

§U.S. Bureau of Mines. 1969 Minerals yearbook. v.1. Washington, U.S. Government Printing Office, 1970.

¶Approximately 8 tons of bauxite are required for 1 ton of aluminum. U.S. Bureau of Mines. Mineral facts and problems. Washington, U.S. Department of the Interior, 1970.

**Darnay, A., and W. E. Franklin. Salvage markets for materials in solid wastes. Washington, U.S. Government Printing Office, 1972, 187 p.

††Approximately 1.6 tons of iron ore and 0.85 ton of coal are required for 1 ton of molten pig iron. Molten pig iron price from Midwest Research Institute. Economic studies in support of policy formation on resource recovery. Unpublished report to the Council on Environmental Quality, 1972.

tax subsidies were eliminated, it is necessary to establish the elasticities of supply and demand for all the major materials under consideration. This information currently does not exist.

While all these factors are significant and introduce considerable uncertainty into predicting what would happen if these tax provisions were eliminated, the fact remains that the virgin material production sector enjoys a significant benefit of over $2 billion annually. The value of the benefits for steel, paper, aluminum, and glass alone amount roughly to $150 million a year not counting the benefit value associated with the energy products necessary to produce these materials. No equivalent tax benefit is provided to industry to support secondary material processing.

The Rationale for Virgin Material Tax Benefits

Special tax provisions for virgin material industries result in a reallocation of resources in a manner different from that which normal market forces would allow. Such a reallocation might be desirable in situations where the free market operation would not lead to overall public benefit or economic efficiency (e.g., for national defense purposes, in instances where substantial risks skew resources away from critical areas, or where there are external costs or external benefits that are not being realized).

Minerals Industry. Tax benefits for exploration and development are aimed at reducing the risk of discovering and developing additional resources, and assuring adequate virgin material supplies. The depletion allowance enables additional investment by providing a fast return on capital. The foreign tax allowances facilitate foreign investment and enable firms to acquire resources outside the United States. However, as these measures either increase profits or reduce material prices, and result in increased produc-

TABLE 29
COMPARISON OF VIRGIN MATERIAL TAX BENEFITS WITH VIRGIN AND SECONDARY MATERIAL PRODUCT COST DIFFERENTIAL

Product	Product cost*		Cost differential in favor of virgin material	Tax benefit as a percent of virgin and secondary material cost differential
	Using virgin material (dollars/ton)	Using secondary material (dollars/ton)		
Glass	18.50	†16.00-20.50	-1.50-2.00	0-8
Steel (molten pig iron)‡	40.50	43.00	2.50	106
Paper:§				
Linerboard (100 percent virgin fiber compared with 25 percent secondary paper)	78.50	81.00	2.50	72
Corrugating medium [85 percent virgin (semi-chemical) compared with 35 percent secondary (semichemical)]	79.50	82.00	2.50	72
Combination boxboard:				
100 percent virgin (kraft) compared with 100 percent secondary (newsback)	152.50	155.50	3.00	60
100 percent virgin (kraft) compared with 100 percent secondary (whiteback)	152.50	174.50	22.00	8
Printing and writing paper (100 percent virgin compared with 100 percent secondary)	92.00	99.00	7.00	26

*Cost at the point in processing where virgin and secondary materials are equivalent inputs. Midwest Research Institute. Economic studies in support of policy formation on resource recovery. Unpublished report to the Council on Environmental Quality, 1972.
†Cost data modified by EPA analysis of current technology and expected transportation distances.
‡Iron ore and coal benefits only. (Benefits to limestone, which is also required to produce steel, are excluded.)
§Cost data modified from Franklin, W. E. Paper recycling; the art of the possible. Washington, American Paper Institute, 1973.

tion and consumption of materials, material reserves could tend to be depleted at a faster rate. Furthermore, by enabling virgin material prices to be maintained at an artificially low level, the development of alternative domestic sources of material and energy could be inhibited (e.g., recycling and energy recovery from post-consumer waste). Therefore, there is some question as to whether these measures lead to conservative use of resources.

There has been one major attempt to estimate the impact of the depletion allowance and exploration and development benefits on the petroleum industry.[10] This study found that elimination of the percentage depletion allowance would result in a long-run decline in oil reserves of about 3 percent, and the removal of the exploration and development expensing provision would result in an additional decline in reserves of about 4 percent. This indicates that in this industry the Federal Government is forgoing tax receipts of about $1.6 billion to maintain reserves that are valued at approximately $150 million.

Timber Industry. Before 1944, capital gains treatment was only allowed when all timber in a stand was cut and sold. Continuous production of timber sold in the ordinary course of business and timber from property held as a capital asset (e.g., a forest owned by a sawmill) was taxed at the normal rate. The rationale for making capital gains treatment available to all types of forestry was that tax pressures to liquidate timber holdings would be reduced and conservative forestry practices such as sustained yield forestry (e.g., growing trees on a particular property at the same rate as they are cut) would not be inhibited. However, a similar argument could have been made for elimination of capital gains treatment altogether. The real question is whether the timber industry would practice optimum forest development in the absence of special tax provisions. If capital gains treatment results in lower timber prices and

increased wood pulp consumption, a more rapid depletion of forest resources might result. In addition, development of alternative (e.g., wastepaper) supplies might be retarded.

It should also be noted that capital gains treatment is allowed for timber harvested from leased Government lands. In this instance, there is no pressure to liquidate holdings as a capital investment by the industries not involved.

In addition to the question of whether virgin material tax benefits lead to a conservative use of resources, there is the question of whether the tax code is the most cost-efficient mechanism for providing benefits. The U.S. Department of Treasury has expressed concern over the use of the tax system for subsidy purposes.

> The main objective of the tax system is to raise revenue for governmental expenditures. Any additional uses should be few in number and should be selected only after the most stringent evaluation. Otherwise, the tax system could become so extensive and so complex that taxpayers would be unduly burdened with complex rules and the administrative machinery would be extended to many times that at present. If we use tax credits too lavishly, we could be building a bigger and bigger tax administration to collect less and less revenue.[11]

Conclusions and Recommendations

Special tax provisions that are available to the virgin material industry provide substantial benefits to this industry. When expressed on a per ton basis, the benefits are equivalent to a significant fraction of the price of virgin raw materials and are an even larger fraction of the difference in cost of using virgin versus secondary materials.

Although it is difficult to estimate the quantitative impact of these measures on material use, they certainly provide opportunity for and encourage expansion and investment in the virgin material sector. To the degree that they are reflected in reduced virgin material prices, they could result in overconsumption of virgin resources and act to inhibit the utilization of materials derived from secondary sources.

A basic dilemma arises when one considers modification or removal of these special tax provisions. The long-term effect might be the conservation of natural resources by reducing virgin material consumption and encouraging the development of materials from secondary sources. However, if in the short term virgin material supply activities are curtailed, there could be serious dislocations and shortages.

Many of these tax provisions were instituted in the past (e.g., the percentage depletion allowance was enacted in 1926) when national emphasis was on industrial development through exploitation of raw material supplies. In light of the current national goals of resource conservation, it is recommended that consideration be given to reevaluation of these tax provisions.

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(Excerpted from: U.S. Environmental Protection Agency, Third Report to Congress: Resource Recovery and Waste Reduction. Washington: U.S. Government Printing Office, 1975.)

Constraints to Energy Recovery System Implementation

Technical and Market Risks. Resource recovery technologies and economics have not been completely demonstrated and evaluated, although systems are currently being marketed and constructed. Some technologies have been projected to operate at an economically attractive cost relative to other solid waste management alternatives. Since most systems have not yet been operated on a full-scale, however, there is some uncertainty about their long-term technical and economic feasibility. This uncertainty results in difficult negotiations over the sharing of risks among the parties concerned. The two major types of risks are technical and marketing risks.

Technical Risks. Technical risks include costs and system operating performance, i.e., the ability of the system to perform as designed at the estimated cost. These uncertainties can be reduced only through

operation of the system at full scale on a continuous basis.

Marketing Risks. The economic success of a recovery system depends on continuing revenues from product sales. If the product cannot be sold or can be sold only at a discount, the projected net cost will not be realized. This could jeopardize a system's ability to meet bond payments.

Long-term market commitments must therefore be sought from the purchasers of recovered energy and materials. These commitments are difficult to secure because potential buyers have had little experience with products recovered from mixed municipal waste. Frequently buyers will stipulate a trial period before signing a long-term contract. Thus "chicken-and-egg" situations develop: A system cannot be constructed until bonds are sold. Bonds cannot be sold unless long-term market commitments are signed with buyers of recovered products. Buyers will not sign long-term market commitments until the system has actually operated and produced over a trial period.

Marketing risks and barriers are not altogether related to the quality of recovered products; some may be more institutional than technical in nature. For example, utilities may be reluctant to purchase shredded waste for use as a fuel because of the industry's traditional use of fossil fuels, their regulated economic structure, or uncertainties as to future air pollution standards for burning of solid waste as a fuel.

In summary, risk related to technical, economic, and market uncertainties is by itself a sufficiently strong force to impede or delay many future implementations, especially because procurements are determined by public works departments that typically have not dealt before with similar risks. Risk will be reduced when more full-scale systems become operational and the information from these systems is made available.

Inadequate Information and Planning. Inadequate information is an impediment to any decision-making process, but it may be a special hindrance in resource recovery implementation because of the rather complex technological, economic, and marketing considerations. Lack of information impacts at the critical phases of planning, system selection, procurement, and financing. Although comprehensive information based on actual operations is not yet available on the different recovery systems, decision-makers considering resource recovery as a solid waste disposal option can and should be aware of the range, general applicability, and stage of development of the technical alternatives that are being demonstrated today.

The selection of an appropriate resource recovery system for a specific locality is a complicated endeavor involving analyses of marketing, management, financial, technical, and legal issues. The failure of municipalities to recognize the importance of the planning process, hire appropriate consultants to guide them, and carry out the planning properly has slowed or impeded system implementation.

Legal Constraints. There are a variety of State laws that could delay or jeopardize the future implementation of resource recovery systems. Three specific types are particularly important:

Laws Restricting Contract Length. Cities often are prohibited from signing long-term contracts for (a) the purchase of a service or (b) the sale of a product. Laws outlawing such contracts effectively preclude a city from entering into a turnkey contract or a full-service agreement by which a corporation offers to build, operate, and manage a resource recovery system for the life of the facility.

Laws Requiring "Split-Bidding." In split-bidding of construction work, the wiring, the plumbing, the bricks and mortar, etc., are bid for separately. This complicates the procurement of proprietary systems.

Competitive Bidding Laws. "Lowest responsible bidder" laws require that procurements be awarded on a cost basis. Awarding contracts on a cost basis alone makes it difficult for a city to compare other important relative measures such as a firm's financial capability and its technical, marketing, and operating experience.

"Lowest responsible bidder" and other procurement laws were instituted for public-sector purchase of risk-free, off-the-shelf technology. They do not work particularly well when applied to the procurement of a somewhat risky resource recovery system because such a purchase, by its nature, almost requires a negotiating period before final signing of the contract. During the negotiation period, risk apportionment (between public and private sector) and specifications for the products and waste

processing can be determined. Unfortunately, reallocation of risk alters costs. Competitive bidding requirements usually make negotiations and revisions of cost illegal.

Although some laws may act as impediments, they usually are not absolute barriers to system implementation. In many cases where laws would adversely affect contract finalizations, cities may petition States for changes in laws or exceptions to the laws.

Availability of Financing

There are two basic sources of capital to finance resource recovery plants: equity financing and debt financing. Thus far, the economic return on investments in resource recovery plants has been too low to attract equity capital. Therefore, most of the focus in plant financing has been on bond market sources of funds: general obligation (GO) bonds of State and local governments, municipal or industrial revenue bonds, and corporate bonds (Table 36).

In times of relative capital shortages, debt financing for recovery plants is very difficult to obtain unless the debt is viewed by investors as "secure," i.e., backed by a municipality (GO bonds) or by a corporation with large financial assets.

Also, the capital markets, especially the debt "track record" must be developed before extensive solid-waste-related industries. Information and a "track record" must be developed before extensive revenue bond financing of resource recovery systems will be available.

Corporate Bond Financing. Recent studies and selected examples suggest that resource recovery plant financing through corporate bonds may be difficult to obtain. Numerous public and private authorities project capital to be in short supply for the next 10 years. For example, the New York Stock Exchange estimated that by 1985 cumulative demands for capital expenditures in the private sector would be $4.7 trillion, while cumulative capital supply would total $4.05 trillion. This indicates a $650 billion cumulative shortfall over that period.

When capital is scarce, projects or corporations that have less than Aa or A bond ratings will have a progressively more difficult time in raising substantial amounts of money in the market. For example, in 1974 (a tight money period), Baa corporations, corporations that have been rated relatively "risky" by the bond-rating agencies, were not able to float any bonds over $50 million, according to a leading investment banking firm. These "risky" corporations, including such firms as Jones and Laughlin, White Motors, Western Union, and Western Pacific Railroad, are better established and have better bond ratings than all but a few firms currently marketing resource recovery systems.

TABLE 36

BOND FINANCING OPTIONS FOR RESOURCE RECOVERY PLANTS

Type	Issuer	Security
Corporate bond	Private company	Faith and credit of the company
General obligation bond	State or local government	Faith and credit of the government entity
Municipal revenue bond	State or local government or special authority	Project revenues
Industrial revenue bond (Pollution control revenue bond)	State or local government	Faith and credit of the corporation*

*Traditionally these bonds have financed pollution control facilities that in reality have no revenue stream. The "revenue" aspect of the bond is the periodic payment from the corporation to the city to retire the obligation. Legally the corporation is responsible to the bondholder. However, with both these bonds and municipal revenue bonds, a contractual agreement may be drawn up in which the municipality pledges an unconditional "put or pay," i.e., agreement to pay a set amount whether waste is delivered or not, and also to escalate dump fees in the event of reduced plant output sales or cost increases. If a city will "put or pay," these bonds are viewed essentially as general obligation bonds.

General Obligation Bond Financing. Though several indicators point to possible shortages of private capital over the next 10 years, the funding of resource recovery plants through municipal general obligation bonds remains a possibility. There does not appear to be any significant prospect of a major shortage of funds for GO bond markets at State or local levels. Thus, public agencies that are willing to extend their general obligation debt for these purposes should not have difficulty in obtaining capital. Decisions of municipal officials on GO bond financing of recovery plants are dependent on several questions. One is simply whether the city is willing to assume the full capital responsibility and associated risk for a plant. Some municipalities have been willing to assume this risk, while others have been reluctant.

The Municipal Financial Officers Association reports that most cities are not near their statutory debt ceiling; thus, this factor should not constrain municipal GO bond financing. However, financing of a recovery plant with GO bonds would generally require voter approval and might require an increase in taxes, a politically unpopular action.

The potential impact on the overall general obligation bond markets of increased municipal recovery plant financing can be predicted. The Federal Reserve predicts a total outstanding State and local debt obligation in 1980 of $370 billion and in 1985 of $548 billion, up from $189 billion in 1973. This is the predicted level of State and local funding considering both demand and supply of capital. Assuming that 30 municipally financed plants costing an average of $50 million each are constructed by 1980, capital requirements would total only $1.5 billion, a negligible fraction of total outstanding debt by 1985. On a yearly basis, the Federal Reserve prediction suggests an increase annually of about $25 billion in outstanding debt (net increase taking into account new obligations and retirements). Even if as many as 15 plants were financed in a single year (an unlikely occurrence), the recovery plant financing would constitute only 3 percent of the increase in State and local debt in that year. Thus, it appears unlikely that general obligation bond financing of recovery plants would have any significant impact on municipal bond markets in the aggregate.

Revenue Bond Financing. Revenue bonds are similar to general obligation bonds except that they are guaranteed by the revenues of a project, not by the full faith and credit of a State or local government. Because resource recovery technology is relatively unproven and realization of projected revenues is uncertain, revenue bonds are somewhat more difficult to sell, unless they are backed by the full faith and credit of a public or private corporation. However, if private, the corporation must be large and well financed to attract potential bond purchasers, who are not willing to take risks on new technology with small corporations. In the case of a public corporation, a city or State must agree to guarantee the bonds in order to reduce the bondholders' risk in financing a new technology.

Availability of State Financing. A final factor that can influence recovery plant financing is State programs for such financing. The funding levels of many of these programs are small relative to resource recovery plant costs. To date only one State, New York, has grant funds sufficient to influence plant financing significantly, and only one State, Connecticut, has a large bond authorization.

Summary. It appears that financing of recovery plants through corporate bonds or revenue bonds over the next 5 or 10 years could be difficult. However, general obligation bond financing should be possible. Pollution control revenue bond financing should be available if backed by a major corporation or if tied (by contract) to a guaranteed coverage of plant costs by cities. States will provide some financing but the amount is unclear. Thus, there is evidence to indicate that there is not, nor will there be, a major capital availability problem for resource recovery systems.

MUNICIPAL SOLID WASTE FACILITIES

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Local government traditionally has held primary responsibility for the collection and disposal of municipal solid waste. Today, more and more counties and states are assuming some or all of this responsibility in order to realize the increased efficiencies and cost savings that often accompany regionalization. Unlike waste water treatment projects, the federal government has not provided broad financial support for solid waste systems. Federal participation has been limited to grants for planning and demonstration of disposal technology. The private sector always has been involved in collection and disposal services, and the concept of resource recovery from solid waste invites an expansion of this role.

Because of the nation's need to conserve both energy and material resources, increased attention is now being focused on solid waste management/resource recovery systems by all levels of government and the private sector. The high capital requirements for recovery facilities and the new risks associated with commercialization of these systems are forcing governmental units and the private sector to re-evaluate their roles in the institutional structure.

This article discusses various methods available for financing municipal solid waste management facilities. Particular attention is given to the developing roles of governmental entities and private sector participants.

PRIMARY SOLID WASTE MANAGEMENT OBJECTIVES

Solid waste management plans at all levels of responsibility should meet four primary objectives:

- Provide a collection and disposal service at the lowest possible net cost to the participating communities;
- Provide for a reliable system capable of handling and disposing of waste on a daily basis;
- Optimize the recovery and recycling of valuable resources; and
- Process waste in an environmentally sound manner that is acceptable to the participating communities.

A balancing among these objectives is necessary because, in a resource allocation sense, they conflict. For example, optimizing recovery may not be consistent with lowest possible cost.

ROLES OF PARTICIPATING PARTIES IN SOLID WASTE MANAGEMENT

There must be a clear understanding of the existing and potential roles of the participating public and private parties in order to develop an appropriate balance among these objectives – particularly when exploring financing vehicles.

The Federal Government

The primary responsibility for solid waste management at the federal level rests with the Office of Solid Waste Management Programs of the U.S. Environmental Protection Agency (EPA). EPA activities have been directed toward the development of regulations and guidelines, research and development, planning assistance and in providing grant assistance for demonstration projects. The basic federal legislation supporting this activity is the Solid Waste Disposal Act of 1965, as amended by the Resource Recovery Act of 1970.

EPA's demonstration grant program, under Section 208 of this act and other accounts, has funded a number of major solid waste projects throughout the country, including: The State of Delaware; San Diego County, Calif.; Franklin, Ohio; St. Louis, Mo.; Lowell, Mass.; and Baltimore, Md. Further funding of demonstration projects on a significant level would appear unlikely.

Of more immediate promise in terms of financial assistance are the funds being set aside by EPA under Section 204 for assistance to governmental agencies in preparing plans for Energy Recovery Implementation Programs. Total funds available in this program are currently $300,000 to be spread over six different projects. This fund will probably be increased to encourage planning on the state and local level. In short, federal assistance is limited, and is likely to continue to be limited to the important planning step. Solid waste management must look elsewhere for implementation and operating resources.

Several legislative packages for federal participation in state and local solid waste management systems have

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. . . Financing Alternatives

been proposed. Generally, these have had the form either of federal guarantees on local debt for solid waste facilities, or a program by the federal government to purchase local debt instruments for the construction of facilities. Grant programs similar to that provided under the Clean Water Act are considered unlikely at this time.

State Government

Many state governments in addition to assuming a major role in solid waste management planning, are also becoming involved in the development and implementation of solid waste management programs, including financing. The scope and type of participation differs significantly from state to state and requires constant updating to keep track of changing legislation and implementation programs. Financial assistance at the state level includes state ownership, state grants, and state loans or loan guarantees.

State Ownership

A prime example of statewide ownership is the Connecticut Resources Recovery Authority (CRRA) which has been given the authority to plan and implement a statewide solid waste management program. The CRRA plans to finance and construct a series of state-owned regional facilities for recovering materials and energy from, and disposing of, solid waste. The CRRA is empowered to issue bonds guaranteed by the state, and enter into contracts with municipalities to provide solid waste disposal services. Revenues generated from municipal disposal contracts and the sale of recycled materials will be sufficient to repay the bonds and pay for operating and maintenance costs.

The facilities are to be constructed and operated under contract by private sector corporations; ownership, however, will remain with the CRRA. The chief advantages to statewide planning and financing are:

- The credit of the state behind the financing assures the salability of bonds at favorable interest rates and terms; and
- Regional planning and funding are easily facilitated.

In the case of Connecticut, municipalities are given the right to reject participation in the state plan and can develop and implement their own individual programs.

State Grant Programs

New York is an example of a state with a grant program geared to provide an incentive to communities for construction of solid waste recovery facilities. New York has authorized the sale of $175 million of general obligation bonds, the proceeds of which are to be utilized throughout the state in the form of grants to communities or regions. Communities or public agencies constructing recovery facilities are eligible to receive grants of up to 50 percent of the planning and construction costs.

The state grant program has the advantage of reducing the cost of financing to the local communities, plus providing the state a mechanism for encouraging regional planning.

State Loan Programs

Some states are considering providing loans to communities and authorities constructing waste facilities. In Pennsylvania, a law providing for such loans has been enacted. The loan would be limited to a percentage of the project costs and the rate would be established by the state, presumably reflecting the cost of state bonds. This type of program provides for state involvement in planning and implementation, and is designed to reduce the cost of financing to local communities.

State Guarantees or Purchase of Municipal Obligations

To strengthen the credit of local communities, some states are considering guaranteeing the repayment of local bonds for solid waste facilities; or, in some cases, purchasing the obligations of the municipalities at some agreed-upon interest payment. These programs again involve the state in solid waste management and serve to lower interest costs to participating communities.

REGIONAL AND LOCAL GOVERNMENTAL ALTERNATIVES

As indicated, responsibility for solid waste disposal has largely remained with local or regional governmental units. Financing at the regional or local level has been done using conventional municipal debt instruments, i.e., tax-exempt municipal bonds. These bonds can be general obligation of the community or revenue bonds based upon anticipated revenues from operation of the facility. No attempt is made here to review the multitude of alternatives for local and regional financing.

INDUSTRY ROLE IN SOLID WASTE MANAGEMENT

The private sector has become increasingly more active in the construction, operation and ownership of solid waste facilities.

. . . Financing Alternatives

The primary motivating factor in this development has been the requirement for more complex recovery technology and the need to incorporate marketing skills for the sale of recyclable materials and recovered energy. A large number of private corporations now offer a total systems approach for solid waste management, including resource recovery. The advantages of private ownership and operation of solid waste facilities generally are thought to be:

- Private industry, being the primary source of resource recovery and recycling technology, is in a better position to assess the risks inherent in the emerging processes;
- Private industry is able to operate and maintain a facility in a more efficient and economical manner; and
- The marketing skills required for profitable utilization of recovered materials and energy values are more abundant and more effectively utilized in the private sector.

Several factors have limited participation by the private sector in the development of waste management systems:

- The traditional role of the community in management of its own solid waste;
- The reluctance of a municipality to accept increasing costs of disposal as lower cost alternatives, such as landfill and incineration, become unavailable;
- The lack of legislative authority (or the existence of constraints) of some communities to enter into long-term contracts or agreements with the private sector;
- The unwillingness on the part of some communities to rely on the private sector for providing such a fundamental service as waste disposal; and
- The widely-held belief that public sector financing of solid waste facilities is less expensive than private sector financing.

FINANCING ALTERNATIVES FOR PRIVATE SECTOR FACILITIES

While the financing alternatives for the private sector are numerous, the fundamental tool for financing solid waste facilities is the Pollution Control Revenue Bond (PCRB). These bonds resemble state or local obligations in that the owner of the bonds is exempt from paying federal income and certain state taxes on interest income received. Obviously, the interest rate on such bonds is significantly lower than it would be for non-tax-exempt bonds of identical credit.

Under the 1968 Internal Revenue Code, privately-owned solid waste facilities can be financed using tax-exempt PCRB's. Under Internal Revenue Service (IRS) regulations, tax-exempt bonds can be used for a facility, providing at least 65 percent of the raw material processed by the facility is solid waste, i.e., that it has no market value at the source. This certainly seems to describe municipal refuse today. There is no telling, however, what interpretation the IRS may put upon this definition. As of the time of this writing, the IRS is allowing tax-exempt bond financing for all but steam boilers or electric generation for sale of energy.

(Editor's Note: As of publication date, the IRS was reviewing the use of Pollution Control Revenue Bonds for financing solid waste facilities. Rulings are pending for five facilities. The IRS has indicated that it may restrictively interpret the Code and not qualify significant portions of a resource recovery plant for tax-exempt PCRB's if it is judged that the facility has "significant purposes" other than disposal of waste or recovery of resources from solid waste.)

Tax-exempt financing can be accomplished utilizing public authorities at the state, county or municipal level, specifically set up for the purpose of issuing Industrial Revenue or Pollution Control Bonds. It is available in 48 states.

The bonds issued are not secured by the credit of the issuing authority, nor are they obligations of any governmental agency. Rather they are secured by the credit of the participating corporation, or done as a project financing and secured jointly by contractual agreements between the private and public sectors.

It is important to recognize that by using PCRB financing, not only does the solid waste facility benefit by obtaining the tax-exempt financing rates, but the private sector operator is considered to be the owner for tax purposes and can retain the full federal and state tax benefits of ownership, including depreciation and investment tax credit. This significantly reduces the true cost of financing, and in many cases leads to a reduction in that portion of the tipping fee required for amortization of debt. The combination of tax-exempt financing and federal tax benefits makes private financing of solid waste facilities a most attractive possibility.

Structure of the Private Financing Alternative

Figure 1 shows a schematic sketch of an idealized structure for private financing of a solid waste facility.

A public authority sells bonds, through an investment banker, to the public. Purchasers typically are major financial institutions.* The interest income on the bonds is exempt from federal income taxes, and in some instances, state taxes as well.

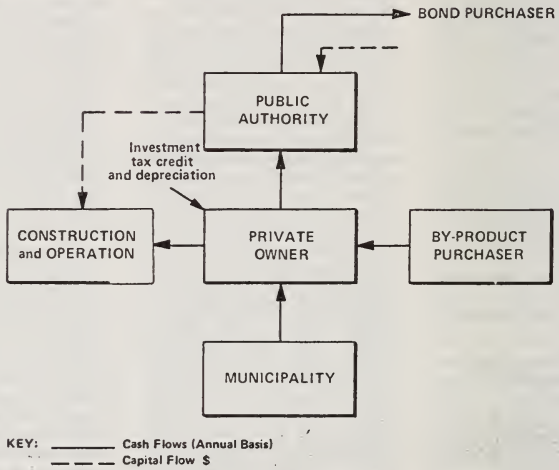
The bond proceeds are held in trust, invested, and used as necessary to pay for the engineering, construction and testing of the solid waste facility. Generally, the bond proceeds also can be used for legal and financing fees associated with marketing the bonds, research and development, interest during construction, and start-up charges.

In a typical transaction, the title to the facility and the land is held by the authority and leased by the authority to the private sector participant. In most PCRB financings, the repayment of principal and interest of the capital is guaranteed by the private sector participant and/or its parent organization. In no case of private financing are the bonds the "direct" obligation of the authority or any governmental agency.

* The sale is in advance of the start of construction of the facility and is for the entire amount necessary to complete the facility.

Figure 1

Financing Solid Waste Facilities
Pollution Control Revenue Bonds



. . . Financing Alternatives

In the case of privately financed solid waste facilities, repayment of the principal and interest may be secured by a number of separate agreements:

- The agreement between the authority and the contractor to complete construction of the facility and to pass certain preliminary start-up tests.
- An operating agreement between the private company and the authority to operate the facility for the term of the bonds at some guaranteed throughput and at an agreed upon service charge, perhaps with a cost escalator.
- Contracts between the participating municipalities and the operator requiring the municipality to guarantee a continuous flow of solid waste accompanied by some guaranteed tipping fee.
- Contracts between the operator and by-product purchasers specifying the quantity, quality, and price of by-products they will purchase.

The income from the guaranteed tipping fees augmented with guaranteed by-product sales must exceed all costs of operations and leave sufficient revenues for interest and principal amortization of the bonds to secure the bonds. The strength of the financing is dependent upon the strength of the contracts and the financial responsibility of the contractual parties.

One of the major advantages of the private financing alternative is that ownership, for tax purposes, vests in the private sector. Accordingly, private industry can take full advantage of allowable depreciation and investment tax credit not available to the public sector.

Leverage Lease Alternative

Another mechanism of private financing is the leverage lease. In this case, a lessor is positioned between the authority and the private company. The lessor leases the facility to the operator. In this type of financing, the lessor is required to put up some equity, generally 25-35 percent of the cost of the facility. In return the lessor obtains the tax benefits of ownership and retains any residual value of the facility remaining at the end of the lease term. The advantage of this type of financing is that the operator pays significantly less in lease payments than he would in the direct bond case because he has given up the rights to the tax benefits of ownership.

SUMMARY

There are many variations of the basic alternatives described above. However, private sector financing of solid waste facilities has many advantages, the main one being the availability of the lowest net cost of financing. This is offset to some degree by the requirement of the private sector participant to show a profit for his financial and technical risk. Private sector participation and financing of solid waste facilities seem to be an appropriate vehicle for sharing the risks and rewards associated with the development and implementation of a new recovery facility.

TAX-EXEMPT FINANCING FOR

The following is a guest article by Eugene Wingerter, Executive Director of the National Solid Wastes Management Association. It is presented in order to clarify for NCRR Bulletin readers the Internal Revenue Service regulations on tax-exempt financing of solid waste management/resource recovery facilities.

In early 1975 the solid waste management and resource recovery industry became greatly concerned over proposals circulating within the Internal Revenue Service (IRS) which threatened to restrict tax-exempt financing under Section 103(c)(4)(E) of the IRS code for solid waste facilities where limited resource recovery activities would take place. The questions raised by the IRS threatened to further delay or prevent the construction of new facilities at a time when market conditions were already limiting the availability of financing for these systems.

In 1968, Congress authorized tax-exempt industrial development bonds for the construction and operation of solid waste disposal/resource recovery facilities. The Department of the Treasury, Internal Revenue Service, Division of Tax Policy, issued regulations to comply with this legislation. It appeared that these regulations clearly defined solid waste disposal facilities eligible for tax-exempt financing to include facilities which disposed of solid waste through recycling. The definitions for Section 103(c)(4)(E) stated that:

"...a facility which disposes of solid waste by reconstituting, converting, or otherwise recycling it into material which is not waste shall also qualify as a solid waste disposal facility if solid waste (as defined by the definition in this section) constitutes at least 65 percent, by weight or volume, of the total materials introduced into the recycling process. Such a recycling facility shall not fail to qualify as a solid waste disposal facility solely because it operates at a profit."

The reasoning offered by IRS officials on the issue of restricting eligibility of tax-exempt financing for solid waste/resource recovery facilities seemed particularly unclear and unexpected, especially at this time, in light of recent legislative proposals to promote resource recovery as a partial solution to our nation's solid waste disposal requirements. There appeared to be a misinterpretation of the fundamental and primary role of a waste disposal/resource recovery facility.

After discussions with officials of the U.S. Treasury Department and industry organizations engaged in the design, construction and operation of large scale municipal solid waste disposal/resource recovery facilities, it appeared that the primary issue regarding eligibility for tax-exempt financing was not the nature of the solid waste disposal facility, but rather the resource recovery functions performed at such a facility. Unfortunately, some members of the Department incorrectly assumed that resource recovery programs were profitable, commercial ventures that no longer needed special

RECOVERY FACILITIES

financial incentives and support. They were unaware that in most cases the cost of disposal at a resource recovery facility was substantially higher than the cost for direct sanitary landfill; that the markets for secondary materials are still unstable and any revenues derived through the sale of recovered materials or energy only serve to offset part of the total disposal cost; and that in general, the immediate justification for these projects is environmentally preferable waste disposal for the community.

The Department was considering limiting tax-exempt financing to only that part of the total cost of the facility that was directly associated with the solid waste disposal function and excluding the capital costs of those related parts of the facility attributed to a processing and recovery function. For example, a facility designed to process solid waste from a community through incineration would qualify as a solid waste disposal facility. However, the heat generated during the combustion process, if recovered and converted to steam, which in turn was marketed to a potential user of such energy, would not qualify as a solid waste disposal activity. Any cost associated with the construction of the energy recovery component of the waste disposal facility would not be eligible for tax-exempt financing. If the energy generated in a thermal reduction process such as incineration were allowed to vent into the atmosphere rather than be recovered and converted to steam, then the entire cost of the facility would qualify for tax-exempt financing. This interpretation appeared incongruous with existing regulations and the current intent of Congress.

The National Solid Wastes Management Association forwarded recommendations to the Department for use in determining eligibility of solid waste disposal/resource recovery facilities. The Association carefully analyzed the applicable regulations in the context of the various waste disposal/resource recovery facilities and systems currently proposed for tax-exempt financing. It was shown that the objective in all cases is identical – that is, to provide the community with an acceptable waste disposal service regardless of the amount of processing and resource recovery activities that may occur in providing this service.

The Association was concerned that any attempt by the Department to separate and exclude specific material or energy recovery components of the waste disposal facility from tax-exempt financing would discriminate against varied technologies under consideration. The Association stressed that any clarification of IRS policy should be based upon the predominant purpose of the facility (*i.e.*, whether it provides a community with a waste disposal service, and not upon any specific technology).

On June 20, 1975, the Internal Revenue Service issued revised regulations identifying where tax-exempt industrial development bonds will be allowable for waste disposal facilities with resource recovery functions. The regulations stated affirmatively that:

> *"A facility which otherwise qualifies as a solid waste disposal facility will not be treated as having a function other than solid waste disposal merely because material or heat which has utility or value is recovered or results from the disposal process."*

The regulations also included as a function of the waste disposal process the processing of materials or heat into the form in which the materials or heat are in fact sold or used, but not into other products. For example, a company would be allowed, as part of the process eligible for tax-exempt financing, to "separate, sort, size, clean, and pulverize glass or metals to make them commercially marketable." Furthermore, if the remaining wastes are burned in an incinerator, an electrostatic precipitator used to clean the gases generated by the incinerator will be considered "functionally related and subordinate to disposal of the waste residue and is, therefore, property used in solid waste disposal. The disposal function includes the equipment actually used to put the heat into the form in which it is sold. . . even if it requires equipment more costly than might be required to produce steam for some other uses."

We believe these revised regulations of the IRS under Section 103(c)(4)(E) clearly recognize the changing technology for waste disposal and the functional aspects of materials and energy recovery that are becoming an integral part of the waste disposal process in many of the new waste disposal systems under development by communities throughout the country. These regulations in our opinion conform to the intent of the original regulations to limit the application of tax-exempt financing to facilities whose primary function for a community is waste disposal.

Garbage-to-Energy Conversion Fuels Bond-Sector Interest

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White Weld Sells $30 Million Issue for Plant in What Could Become a Trend

Aug. 11, 1975 p. 19.

By LINDLEY B. RICHERT
Staff Reporter of THE WALL STREET JOURNAL

NEW YORK — "Garbage" may be the way municipal bond specialists would characterize their entire market recently, but its aroma holds particular interest for those at White, Weld & Co.

On Friday, the investment bankers successfully offered $30 million of new tax-exempt revenue bonds, designed to complete construction of the largest refuse-to-energy plant in the U.S. Financing for that facility, expected to be operational about Oct. 1, is among the first of what could be more than a $5 billion industry total over the next 10 to 15 years, estimates Peter Philip, senior vice president at White Weld.

Located on a former landfill site in Saugus, Mass., this plant will burn, for a fee, the garbage of at least 10 surrounding towns in that Boston North Shore area. The heat will fire huge boilers that, in turn, will provide steam energy to General Electric Co.'s nearby Lynn River Works plant. The abundantly available garbage will permit two of GE's eight oil-fired generators to be mothballed at an estimated savings of about 17 million gallons of fuel oil annually.

The idea of "garbage power" isn't new, at least outside the U.S. Because of natural and economic constraints, Europe and Japan learned long ago to turn refuse into energy. The Saugus facility is of essentially the same design as that pioneered by Von Roll Ltd. of Zurich, Switzerland, about 20 years ago.

Resource-recovery plants using the technology, either in operation or being built, total 67. They're located in Europe, Japan, Canada and Australia. In addition, there are 34 plants in operation and another 15 being built that are similar to the Saugus plant but don't recover the energy generated. Besides recovering the energy content as steam at Saugus, the process also permits extraction and, hence, sale of ferrous metals from the ash—another revenue source to secure these bonds. The ash, itself, is usable as a roadway base or building-block component.

In the U.S. alone, more than 200 million tons of domestic refuse is collected annually. Converted to electric energy, it represents a generating power of about 14,000 megawatts of power, or the fuel equivalent of about 290 million barrels of oil—roughly two-thirds the yearly U.S. import of Arabian crude oil, says a spokesman for Wheelabrator Energy Systems Inc. That subsidiary of Wheelabrator-Frye Inc., in joint partnership with M. DeMatteo Construction Co., will operate the Saugus plant.

"You can figure one ton of refuse is the energy equivalent of one barrel of oil, or one-third ton of coal," explains Clay Stephens, president of Wheelabrator Energy.

Jersey Central Power & Light Co. signed a 25-year contract this spring with the Wheelabrator unit to buy nearly one billion kilowatt hours of electricity a year from a garbage-fueled generating station to be built on a site as yet undetermined in central New Jersey. At the time, Wheelabrator said the utility was attracted chiefly by the guarantee of an on-going energy supply. Jersey Central will save 150,000 gallons of fuel oil a day, Wheelabrator says.

An unspecified number of other plants are in various stages of negotiations, Mr. Stephens adds.

Last week, American Can Co. began building an $18 million resource-recovery facility in Milwaukee that is designed to process up to 400,000 tons of that city's solid waste annually. "We are confident this is the coming thing," says a company official. Cost of that plant will be financed internally, American Can adds.

The Saugus bonds, rated single-A, included $16.1 million of 19-year 8% bonds priced at 100, and $13.9 million of serial securities, scaled to yield between 5.75% in 1977 and 7% in 1985.

VI. RESEARCH, HAZARDOUS WASTES, AND SEWAGE SLUDGE

(Excerpted from: Compilation of Papers from Third National Congress: Waste Management Technology and Resource Recovery, co-sponsored by National Solid Wastes Management Association and U.S. Environmental Protection Agency. /Washington?/ National Solid Wastes Management Association, 1975.)

THE VIEWS OF THE ACADEMIC COMMUNITY ON SOLID WASTE MANAGEMENT RESEARCH PRIORITIES

Dr. Eugene A. Glysson
Professor of Civil Engineering
University of Michigan

These views are based on discussions at a recent meeting of professors involved with solid waste management programs at twelve leading universities around the country.

Research is being carried out in many different areas, but it can be grouped to some degree which might indicate priorities.

A great deal of interest is shown on the effects of disposal methods on the environment. This is indicated through research on such subjects as leachate quality and treatment. Practically every program represented was doing some research work on some aspect of the leachate problem. These studies included work on leachate characteristics, different methods of leachate treatment, presence of heavy metals in leachate from mixed refuse and from incineration residues. (Much work is needed on the fate of heavy metals in soils.) Studies on establishing the bacterological quality and virus content of leachate are being conducted. Research leading towards the standardization of methods of analyses needed to evaluate leachate quality is being carried out.

Another area of major interest is related to research on biological processes involving such things as methane production by anaerobic digestion and ethanol production.

Another area involves the problem of sludge disposal which is being studied by several researchers. These range from water treatment and waste water treatment sludges to those produced by various industries such as the petroleum industry. Sludges resulting from air pollution control are also being considered.

As indicated by these activities a major share of the emphasis in this research is toward land disposal and the accompanying environmental effects. Researchers are trying to identify mechanisms which take place when wastes are disposed of in this manner so that it will be possible to predict and thus prevent unfavorable conditions from developing.

There is interest as well in applying systems analysis to solid waste management. Methods of optimizing collection operations have been developed; more work towards implementation is required. A method of using decision theory to assist in solid waste disposal site selection has been formulated.

This on-going research shows an active interest on the part of the academic community in solid waste management. However, there is another subject that has a high priority with those of us who are in the teaching community and that is the need for continued support for training.

We can expect more and more sophistication in solid waste management as greater emphasis is placed on proper treatment and disposal of both domestic and industrial solid wastes. Toxic and hazardous wastes are going to require more careful consideration. More semiliquids and sludges will be handled than before. More emphasis will undoubtedly be placed on environmental considerations. All of this activity can only be carried out effectively if trained personnel are available. Both the public and private sector will need competent people to deal with the types of wastes being generated and disposed of.

I feel that it is of the highest priority then that support for a continuing program of solid waste management training in the universities be maintained so as to provide the technical competence needed in the future. Such a training program in the universities not only produces technically trained people but provides the identity needed to focus attention in the field of solid waste management which attracts qualified students into the profession.

Programs devoted to solid waste management should be able to compete with air and water programs for competent students since the environmental and economic impact of solid wastes are no less important. Many of the people presently involved in the public and private sectors have benefited from this type of training and now is the time to increase support for these programs as we become more concerned with hazardous and toxic wastes as well as resource conservation.

In conclusion, it is my view that the academic community will continue to assist in the search for solutions to the environmental problems associated with solid waste management and we seek your support in providing the technological competence needed to implement these solutions.

UNIVERSITIES ATTACK SOLID WASTE

This article was written for NCRR Bulletin by David Gordon Wilson, professor of mechanical engineering at Massachusetts Institute of Technology. Dr. Wilson has actively pursued his concerns in the fields of resource recovery and transportation combined with his background in engineering. He has supervised the development of solid waste resource recovery techniques over the last four years for the U.S. Environmental Protection Agency; served on the Massachusetts special legislative commission on the reuse of solid wastes; jointly supervised the National Science Foundation project on surveying policy-related research in solid-waste; and has been a member of the panel on alternative engines of the committee on motor vehicle emissions of the National Academy of Sciences for the last three years.

UNIVERSITIES have frequently – and unjustly – been taken to task for allegedly ignoring the environmental threat to our standard of living. Actually, several universities are doing important work in the area of resource recovery. Universities, a term which means, in this context, individual members of various faculties, attack problems partly because they want to and partly because they either have free time and discretionary funds or because there are funding agencies willing or anxious to spend money. There is no shortage of academics who want to work in the resource recovery area. Many have been supported over the last six years by funds from the Solid Waste Management Act of 1965 or the Resource Recovery Act of 1970.

In the 2000 or so institutions of higher education in the U.S., there are people working in virtually every aspect of resource recovery. We, therefore, have to be very selective. We shall not be concerned here with "soft" studies – legal, institutional, regulatory, markets and so on. There is also much activity on the reuse of separated materials – for instance on the conversion of paper products to building boards; of glass to road-surfacing compound; or organic materials generally to heat; and of almost anything to building bricks. We shall overlook this body of work too so that we may concentrate simply on the smaller number of projects which are directed at the recovery of consumer wastes.

CRYOGENIC TREATMENT OF AUTOMOBILE TIRES

About 200 million tires are discarded each year in the U.S., with a decreasingly small proportion going to recappers. Less than 10 percent of discarded tires are reclaimed for making such things as floor mats and battery cases. At many times and in many places over the last century, ground rubber has been used in asphalt for road surfaces and has been shown to give a potentially superior performance over traditional asphaltic cements. Rubber from tires can be successfully pyrolyzed into ash, fuel oil and fuel gases, and can even be used as a basis for the growing of yeast. Some of these potential uses could absorb all the scrap rubber in discarded tires.[1] However, all these uses require the separation of the bead wire and any steel-belt reinforcement from the tire; in some of them, separation of the fabric is also necessary. All processes also require that the tires be reduced to a small particle size.

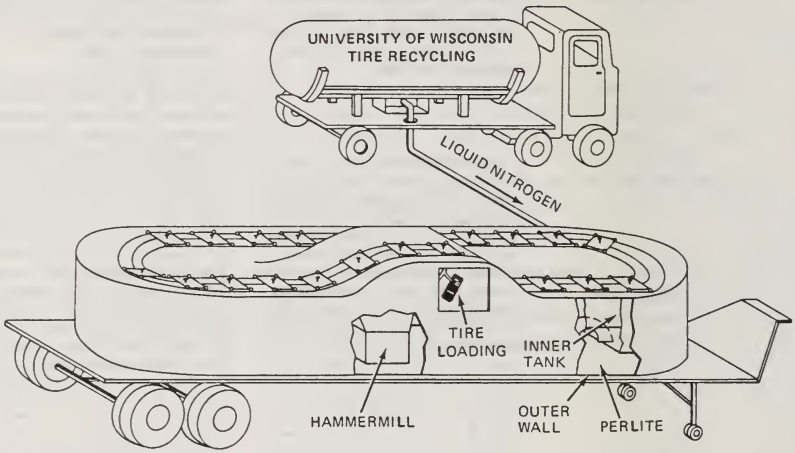
. . . Research in Recovery

Professor Norman R. Braton, of the Mechanical Engineering Department of the University of Wisconsin at Madison, hopes to reduce the cost of producing ground rubber by comminuting tires at low temperatures.[2] Prof. Braton has found that the tires need to be lowered to $-80^{\circ}F$ to ensure that they are below the glass point. He has used both liquid nitrogen ($-319^{\circ}F$) and mechanical refrigeration ($-83^{\circ}F$) before subjecting the tires to hammermilling. The impacts have resulted in instantaneous fragmentation of the rubber materials and almost complete and virtually automatic separation of wire and cords from the rubber materials. In addition, the original volume of the tire is reduced by 82 percent.

The goal of the University of Wisconsin research team is to develop a portable mill which can be moved from city to city to fragment and separate 30 tires per minute (Figure 1). If such a mill worked three shifts per day, it could process more than 40,000 tires, or 400 tons per day. Only 20 such mills would be required to handle the country's automotive tire wastes.

The work by the University of Wisconsin's College of Engineering, Physical Science Laboratory and University Industry Research Group is supported by a local Wisconsin industry.

FIGURE 1



Cryogenic Tire Recycling — University of Wisconsin

. . . Research in Recovery

NON-FERROUS SCRAP SEPARATION BY INDUCTION

When an automobile is shredded in a hammermill, the non-ferrous and stainless steel materials can be separated from ferrous materials by magnetic belts or drums. Traditionally, the larger non-ferrous items are sorted by hand by picking from a belt. The pieces below a limiting size (at which the labor of handpicking would not pay for itself) are discharged as mixed non-ferrous materials. Claims are made from time to time that a process has been developed which will sort out non-ferrous materials at least into copper, brass, aluminum alloys, magnesium alloys, and zinc alloys, but so far no process has been proven in practice.

A promising technique has been developed at Vanderbilt University, utilizing the repulsive forces from eddy currents induced in metals falling in high magnetic-field gradients. A spin-off from the Vanderbilt experiments has produced a company, Magnetic Separation Systems, Inc., which is carrying on the work with eddy current separation on a commercial basis.

REFUSE HYDROLYSIS

Cellulose hydrolysis applied to refuse disposal is a relatively new process conceived by Dr. A. Porteous, formerly of Dartmouth College, N.H., now of the Open University, Milton Keynes, U.K.[3] So far as is known, this process has not been previously applied or proposed for refuse disposal although there are recorded applications of it to cellulosic materials such as cotton hulls and hardwoods. The hydrolysis of wood was extensively employed in the U.S. during World War II but had a swift demise in the post-war years. The reasons for this demise seem to be mitigated by new developments and the use of refuse as feedstock.[4] Wood required collection and as transport costs were charged to the feedstock a severe economic penalty was incurred. However, in municipal refuse disposal, the material must be collected anyway and therefore the feedstock can be considered as delivered free to the refuse-hydrolysis plant. The old wood-hydrolysis process was very slow; hydrolysis times on the order of 3-1/2 hours were required with yields of 50 gallons ethanol per ton of wood. In the "Porteous Process" the hydrolysis time is one to two minutes with comparable predicted yields on a "wood" basis of 50-55 U.S. gallons. The large hydrolysis times in the U.S. wood-ethanol process entailed the use of a reactor roughly 200 times greater than that proposed for the present process where the respective plants are handling the same throughputs. The U.S. plants had considerable difficulty in handling the large charges due to frequent blockages in the batch reactor system employed. This led to considerable loss of output. The proposed process has a continuous-flow reactor which in combination with the much lower residence times should eliminate the blockages encountered in the wood-hydrolysis industry.

In the hydrolysis process the refuse is pulverized and discharged into a flotation separator or a special pulper to allow segregation of the refuse into a dense and a light fraction. The pulped fraction, mainly cellulosic material, is then fed to a fines- and plastic-removal section and thence to a reactor for hydrolysis.[5] Flash cooling using the process feed water as coolant, neutralization and filtering follow. Fermentation is then carried out for roughly 20 hours and the resulting 1.7 percent aqueous ethyl-alcohol solution is distilled or rectified to yield 95 percent ethyl-alcohol and 5 percent water. A waste liquid stream is also discharged which requires treatment for reduction of biochemical oxygen demand.

COMPUTER-BASED MECHANICAL SORTING OF MUNICIPAL REFUSE

So far as is known, the only complete system dealing with mixed municipal refuse under development in a U.S. university is the M.I.T. process which received four years' funding from the Environmental Protection Agency. The principal features of the M.I.T. approach are that the larger pieces of refuse are first sorted out for treatment on an item-by-item basis; these larger items are examined by a number of sensors in series; a decision is made by a minicomputer as to which among perhaps 25 categories the large item should be switched; and subsequently switching is accomplished by means of a bottom-opening cart which passes over a series of hoppers.

Some of the details of the present plant are shown in Figure 2. Separation of the large items is accomplished by means of a two-deck vibrating screen of perhaps eight-inch and four-inch mesh sizes. Loose paper and plastic film are removed by an overhead fan operating on the inside of an open-mesh belt. Separation of this stream into paper and plastic may be accomplished by means of the electrostatic process developed by the Bureau of Mines.[6] A magnet pulls off ferrous materials. The fines passing through the vibrating screens go to a small hammermill to join rejected large items.

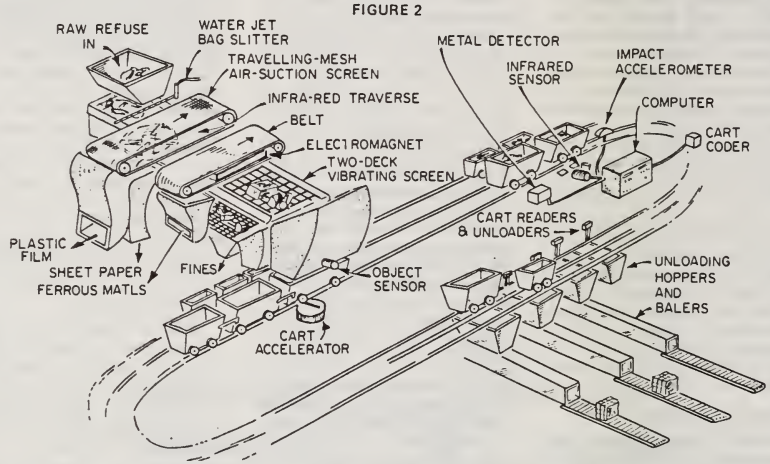
The large items falling off the vibrating screen randomly enter waiting open carts on parallel tracks. As a piece of refuse enters a cart, a sensor operates an accelerator so that it is immediately

removed and an empty cart replaces it to receive another large item of refuse. The full carts are picked up by a steadily traveling chain conveyor and are moved past a series of sensors. Two sensors have been developed (and patented) by M.I.T. for this process. One measures the reflectance of a series of four different infrared wavelengths. The computer compares the reflectance intensity with past experience with known materials and makes a tentative classification. A second sensor vibrates a ball bearing carrying a miniature accelerometer against the the piece of refuse and the computer looks at five numbers obtained from each bounce (for instance, the peak acceleration; the time to zero acceleration). Other sensors in use or to be used are commercially obtainable – a metal-proximity sensor and a color comparator for whole glass bottles. (An analysis of refuse collected by compactor trucks in two widely separated communities showed that about 19 out of 20 glass bottles emerged unbroken.)[7]

The computer algorithm rejects as inhomogeneous those items on which the various sensors cannot agree as to composition. These items are then taken to the small hammermill, joining the fines which passed through the vibrating screens.

The hammermill product is again screened for size and passed to a vortex classifier. This classifier, which again has been under development and has been patented at M.I.T., takes a stream of particles into a radially inward-flowing vortex of air or water.

FIGURE 2



Computerized Large-Item Refuse Sorter, Massachusetts Institute of Technology

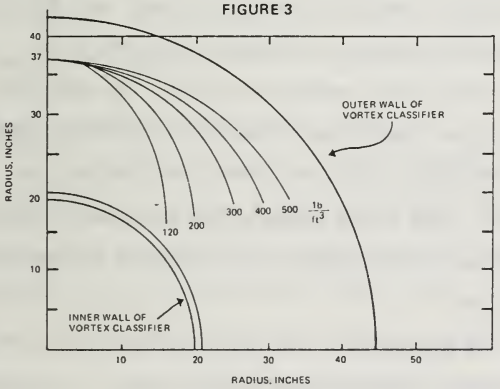
. . . Research in Recovery

Air is used for the less-dense materials, principally organic, while water is used for the inorganic materials such as metals and glass. The aerodynamic forces acting on the particles produce flow paths which depend principally on the density of each particle and to a lesser extent on the drag coefficient. The experimental classifier investigated so far has confirmed that various common shapes of particles take up paths demonstrated by the computer prediction of Figure 3. The shapes so far investigated do not include ragged strips of metal, for which some pretreatment, such as pelletizing, might be advantageous.

The M.I.T. process has been designed to be located in areas where the credit from dumping fees can be expected to be above $6 per ton. With no high-capital-cost components in the system (the minicomputer retails at about $4000) the planned capital cost is expected to be substantially lower than an equivalent-capacity incinerator, with running costs similar to that of an incinerator, and with the possibility of revenue from separated materials growing with time.

Professor Stephen D. Senturia of the Electrical Engineering Department, M.I.T., has supervised the project with the present author.[8]

FIGURE 3



Computer Prediction for Performance of M.I.T. Vortex Classifier Using Water

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RECLAMATION OF ENERGY FROM DOMESTIC REFUSE: ANAEROBIC DIGESTION PROCESSES

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Among the many challenges confronting the world as a whole, and this country in particular, are two seemingly unrelated problems. The first and perhaps the more obvious of the two is a problem of solid waste management. In particular, it is a problem of solid waste disposal. The second is the decline in energy resources as evidenced by the increasing shortage in natural gas reserves. The development of a process to convert organic refuse into methane would provide at least a partial solution to both of these problems.

In wastewater treatment anaerobic digestion has been used for a long time to effectively reduce the quantity of organic sludges and to transform them into stable, more easily dewatered residues. The reduction is accomplished by the biological conversion of the organic solids to methane and carbon dioxide. This anaerobic process has a very low efficiency of biological energy conversion. Most of the energy of the substrate is lost. The gas produced has a high calorific content and is a valuable end product with potential for reclamation.

Various studies have demonstrated that organic refuse, particularly garbage, is amenable to anaerobic decomposition. Organic refuse is composed basically of the same compounds, carbohydrates, proteins and fats as sewage sludge though in different relative proportions. There appears to be no reason why refuse cannot undergo adequate anaerobic decomposition. Proper environmental conditions must be maintained, the deficient nutrients supplied and toxicity problems eliminated.

In addition to providing a means of energy conservation this process provides a significant reduction in the quantity of waste material for ultimate disposal. Assuming that about 70 percent of domestic refuse (dry

weight basis) is biodegradable and that 70 percent of the biodegradable portion is gasified in an anaerobic process, the resulting overall reduction in dry solids would amount to about 50 percent. This will greatly reduce transportation costs to the landfill sites as well as extend the life of the sites.

Moreover, this residue exhibits a very important advantage over the present solid wastes that are disposed of in landfills. Untreated refuse has not been stabilized biologically and is in a process of decay. When placed in a landfill it decomposes and can cause problems if adequate preventive measures are not taken. It can also cause settlements in the fill area that render it unsuitable as a building site. These problems are far less severe with digester residue since it has been biologically stabilized. The development of systems of this type will be a big contribution to the overall problem of solid waste management.

Basic Fundamentals of Anaerobic Digestion

Anaerobic treatment of complex organic materials is considered to be basically a two-stage process as indicated in Figure 1. In the first stage, a group of faculative and anaerobic bacteria act upon the complex organics and change the form of complex fats, proteins and carbohydrates to simple soluble organic materials. The end products of this first stage conversion are primarily short chain organic acids, also known as volatile acids, and small amounts of bacterial cells. This stage accomplishes no stabilization of the waste material but it is an essential prerequisite for the second stage in which the actual stabilization of the waste matter occurs. It places the organic matter in a form suitable for the second stage of treatment.

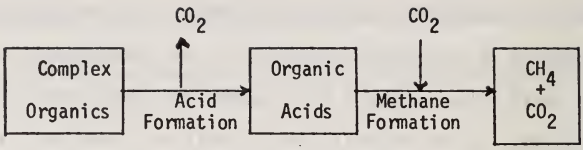

Figure 1. Anaerobic Stabilization of Complex Organics

In the second stage, the short chain organic acids are acted upon by a strictly anaerobic group of methane bacteria and are converted to gaseous end products, methane and carbon dioxide. The methane formed in this stage, being insoluble in water, escapes from the system. It can be collected for use as a fuel. The carbon dioxide involved primarily escapes to the gas phase but a portion goes into solution. It is in this second stage that stabilization occurs through the removal of oxygen demanding material in the form of methane gas. Cell production is also minimal compared to aerobic processes. This is a direct result of the high energy content of the products, in particular methane (McKinney and Conway, 1957). This is an advantage as the amount of biological solids requiring ultimate disposal is minimized by eliminating any significant microbial protoplasm production in the process of stabilizing the organic material.

Summary

Using state-of-the-art for the various unit processes employed in this system, it is possible to produce a significant quantity of pipeline quality gas that can be marketed at a price competitive with other sources of natural gas. The major accomplishment of this work has been the definition of more nearly optimum operating conditions for the digestion and dewatering processes. Operating in the thermophilic temperature range greatly reduces the retention time required to achieve near maximum conversion of the organics to gas. A significant reduction in capital for the digestion system is a result of the short retention time.

Energy costs for heating have been greatly reduced by being able to feed a concentrated organic stream to the digester. The only limit to increasing the feed solids to higher levels with concomitant cost reductions is the 50 percent solids-to-gas conversion factor. If this conversion could be increased, significant reductions in capital and operating costs for both the digestion and dewatering systems could be obtained. The cost of incineration would also be reduced. Additional income would result from the increased gas yield per unit of refuse processed. As the cost of energy, particularly for a premium fuel like natural gas, increases above $\$1.00/10^6$ BTU, the income from the process will also increase.

The economic analysis is highly dependent on the credits for refuse. Based on the current conversion efficiency, the revenue from the gas and ferrous metal does not cover the processing costs. Increases in the energy value or increases in conversion efficiency will be necessary for the income to cover the processing costs.

Widely varying costs have been reported for the various unit

processes employed in this system. The experimental data collected during this study provide the basis for a complete analysis for the cost of the digestion, dewatering, incineration and disposal processes. The cost data for the other unit processes have been taken from Wise *et al.* (1974). These figures appear reasonable based upon available information.

In summary, the technology used in this process is based on commercially available units. The economics appear very favorable. It remains only to conduct a large scale evaluation to refine the design criteria plus the economics.

(Excerpted from: Compilation of Papers from Third National Congress: Waste Management Technology and Resource Recovery, co-sponsored by National Solid Wastes Management Association and the U.S. Environmental Protection Agency. /Washington?/ National Solid Wastes Management Association, 1975.)

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FERMENTATION PROCESSES
. . . A Survey

IN recent years, there has been renewed interest in an old process: using fermentation bioconversion and biosynthesis to convert organic materials to new products. Since World War II, use of fermentation to produce ethanol and other industrial chemicals has taken a back seat to petrochemical processes. Recently, however, there has been increased interest in applying fermentation processes to convert the organic fraction of solid waste to new products, using selected micro-organisms – single-cell animals. Three general types of microorganisms are employed: yeasts, bacteria and fungi.[1]

Several projects are studying the biological conversion of the cellulosic fraction of wastes to glucose (sugar), protein, or such chemical intermediates as methanol for fuel. Thus far, no commercial installations have been built, although several are under consideration.

Despite the early developmental stage of virtually all these projects, they are summarized below because of their potential importance in years to come. The biological conversion of wastes to methane is not reviewed here.

PROTEIN FROM BAGASSE BY BACTERIAL FERMENTATION

In 1971, a 53 ton-per-day pilot plant was designed, built and operated under a U.S. Environmental Protection Agency (EPA) program at Louisiana State University (LSU) to produce single-cell protein by the bacterial fermentation of a waste cellulose (bagasse, or sugar cane waste).[2, 3] The method of production resembles other fermentation processes, such as the production of antibiotics. A large fermentation tank was used with the waste cellulose as food for bacteria. A crude protein results from the bacterial growth and is harvested for possible use as an animal feed supplement.

An agreement was signed in 1974 between Bechtel International and LSU to commercially develop this process, including its use for municipal solid waste.

PRODUCTION OF FUNGAL PROTEIN FROM CELLULOSE

In 1972, a laboratory program was conducted at an EPA laboratory[4] to investigate means of increasing the rate of conversion of waste cellulose to protein by fungi. The basic fungal fermentation used was a method similar to the LSU process. Several methods were studied as means of degrading the cellulose prior to fungal digestion. The methods investigated were: alkali, high temperature acid hydrolysis under pressure, electron irradiation and photo-chemical. This latter method proved superior and is described in the next section.

As a result of this study, a pilot plant to grow fungal protein from waste cellulose has been designed but not built.

PHOTODEGRADATION OF CELLULOSE

It was discovered in 1967, in research not related to waste processing, that cellulose can be degraded by treating it with a particular inorganic salt, such as sodium nitrite, and exposing it to ultra-violet light. In this way, the cellulose molecule is degraded to a form more rapidly utilized by fungi to grow protein.[5]

The presence of sodium nitrite accelerates the rate of photodegradation two- to four-fold. However, 24 to 48 hours of irradiation is needed to degrade the cellulose sufficiently for there to be a significant effect on rate of production of fungal protein. This process appears to be too expensive for commercialization.[6]

FUNGAL ENZYMES TO PRODUCE GLUCOSE FROM WASTE CELLULOSE

U.S. Army Natick Laboratories are researching a process to convert waste cellulose to glucose using an enzyme derived from a strain of tropical fungus.[7,8] The product glucose can be converted to ethanol by usual fermentation routes using yeasts. This particular fungus was discovered during military research on jungle rot and the enzymes isolated from it are particularly fast-acting in degrading celluloses. The Natick Laboratories are planning expansion of the laboratory facility to treat 1000 pounds of waste cellulose per month. If the pilot unit is successful, a larger unit is planned for treating 100 tons per month.

PROTEIN PRODUCTION USING FUNGI FERMENTATION

Tate & Lyle, Ltd., the British sugar producer, is researching a laboratory process to produce protein by the fungal fermentation of cellulosic wastes. The enzyme from the filamentous fungus employed was isolated from rotting carob trees in Greece.[9,10]

This fermentation process is characterized by its ability to operate on cellulose at higher temperatures (97°F) and greater acidity than other similar processes. Also, the particular fungi used break down impurities such as tannins, making the product protein easier for animals to digest.

Tate & Lyle plans to build and operate a one ton-per-week protein plant in a Central American subtropical location.

PROTEIN FROM ALCOHOLS

Wastes can be converted to ethanol by enzymatic degradation of cellulose to sugar and fermentation of the sugar.[11] Also, the product gases from pyrolysis of waste can be used to synthesize methanol. Either of these alcohols can be food for growing protein, according to recent announcements.

Alcohols are the substrates (food) to grow yeasts, which are harvested to provide what is termed "single-cell protein," suitable as an animal feed supplement.[12] One such process, announced by Mitsubishi (Japan),[13] uses acid- and heat-tolerant yeast strains. Ethanol is the substrate, and protein yields of up to 93 percent are reported.

Another Japanese process uses methanol as the substrate and bacteria rather than yeast to produce the protein, with yields of up to 48 percent.[13] A 500-ton-per-year pilot plant was built by Mitsubishi Gas and Chemical Co.

GROWING YEAST FROM SOLID WASTE

There have been economic and technical feasibility studies of the conversion of solid wastes to yeasts. The process would be hydrolysis to produce fermentable sugars and subsequent fermentation. Much of this analysis is based on work originally done in the late 1940's. The market analysis for yeast as a vitamin and protein supplement in human and animal feeds showed that the process was not competitive at the time of the analysis in 1969.[14]

MISCELLANEOUS PROCESSES

Numerous studies are reported for conversion of refuse to useful products by biochemical means. Some of these are summarized below:

It is reported that the Wolfson Laboratory, Cardiff, Wales, U.K., is converting urban waste to high quality protein for animal feed by using selected organisms (unnamed) in a manner similar to a process for deriving protein from oil developed by this group in 1972.[15]

Black Clawson Fibreclaim, Inc., has reported that it has teamed with Gulf Oil Chemicals, Inc., to produce an industrial ethanol from cellulose with glucose as an intermediate. This will be piloted at Black Clawson's Franklin, Ohio, plant.[16]

Georgia-Pacific Corporation chemical plant at Bellingham, Wash., has reported that it is converting spent pulp to high grade alcohol.[17]

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(Excerpted from: U.S. Environmental Protection Agency, Report to Congress: Disposal of Hazardous Wastes. Washington: U.S. Government Printing Office, 1974.)

SUMMARY AND CONCLUSIONS

The management of the Nation's hazardous residues - toxic chemical, biological, radioactive, flammable, and explosive wastes - is generally inadequate: numerous case studies demonstrate that public health and welfare are unnecessarily threatened by the uncontrolled discharge of such waste materials into the environment.

From surveys conducted during this program, it is estimated that the generation of nonradioactive hazardous wastes is taking place at the rate of approximately 10 million tons yearly.[1] About 40 percent of these wastes by weight is inorganic material and about 60 percent is organic; about 90 percent occurs in liquid or semiliquid form.

Hazardous waste generation is growing at a rate of 5 to 10 percent annually as a result of a number of factors: increasing production and consumption rates, bans and cancellations of toxic substances, and energy requirements (which lead to radioactive waste generation at higher rates).

Hazardous waste disposal to the land is increasing as a result of air and water pollution controls (which capture hazardous wastes from other media and transfer them to land) and denial of heretofore accepted methods of disposal such as ocean dumping.[2]

Current expenditures by generators for treatment and disposal of such wastes are low relative to what is required for adequate treatment and disposal. Ocean dumping and simple land disposal costs are on the order of $3 per ton whereas environmentally adequate management could require as much as $60 per ton if all costs are internalized.[3]

Federal, State, and local legislation and regulations dealing with the treatment and disposal of nonradioactive hazardous waste are generally spotty or nonexistent. At the Federal level, the Clean Air Act; the Federal Water Pollution Control Act; and the Marine Protection, Research, and Sanctuaries Act provide control authority over the incineration, and water and ocean disposal of certain hazardous wastes but not over the land disposal of residues. Fourteen other Federal laws deal in a peripheral manner with the management of hazardous wastes. Approximately 25 States have limited hazardous waste regulatory authority.

Given this permissive legislative climate, generators of waste are under little or no pressure to expend resources for the adequate management of their hazardous wastes. There is little economic incentive (e.g., the high costs of adequate management compared with costs of current practice) for generators to dispose of wastes in adequate ways.

Technology is available to treat most hazardous waste streams by physical, chemical, thermal, and biological methods, and for disposal of residues. Use of such treatment and disposal processes is costly, ranging from a low of $1.40 per

ton for carbon sorption, $10 per ton for neutralization/precipitation, and $13.60 per ton for chemical oxidation to $95 per ton for incineration.[4] Several unit processes are usually required for complete treatment and disposal of a given waste stream. Transfer and adaptation of existing technology to hazardous waste management may be necessary in some cases. Development of new treatment and disposal methods for some wastes (e.g., arsenic trioxide and arsenites and arsenates of lead, sodium, zinc, and potassium) is required.[5] In the absence of treatment processes, interim storage of wastes on land is possible using methods that minimize hazard to the public and the environment (e.g., secure storage and membrane landfills).

A small private hazardous waste management industry has emerged in the last decade, offering treatment and disposal services to generators. The industry currently has capital investments of approximately $25 million and a capacity to handle about 2.5 million tons of hazardous materials yearly, or 25 percent of capacity required nationally. However, the industry's current throughput of hazardous waste is about 24 percent of installed capacity, or 6 percent of the national total. The low level of utilization of this industry's services results from the absence of regulatory and economic incentives for generators to manage their hazardous wastes in an environmentally sound manner. This industry could respond over time to provide needed capacity if a national program for hazardous waste management, with strong enforcement capabilities, was created. This industry would, of course, be subject to regulation also.

The chief programmatic requirement to bring about adequate management of hazardous wastes is the creation of demand and adequate capacity for treatment and disposal of hazardous wastes. A national policy on hazardous waste management should take into consideration environmental protection, equitable cost distribution among generators, and recovery of waste materials.

A regulatory approach is best for the achievement of hazardous waste management objectives. Such an approach ensures adequate protection of public health and the environment. It will likely result in the creation of treatment and disposal capacity by the private sector without public funding. It will result in the mandatory use of such facilities. Costs of management will be borne by those who generate the hazardous wastes and their customers rather than the public at large; thus, cost distribution will be equitable. Private sector management of the wastes in a competitive situation can lead to an appropriate mix of source reduction, treatment, resource recovery, and land disposal.

A regulatory program will not directly create a prescribed system of national disposal sites because of uncertainties inherent in the private sector response. EPA believes that the private sector will respond to a regulatory program. However, full assurance cannot be given that treatment and disposal facilities will be available in a timely manner for all regions of the Nation nor that facility use charges will be reasonable in relation to cost of services. Also, private enterprise does not appear well suited institutionally to long-term security and surveillance of hazardous waste storage and disposal sites.

Given analyses performed to date, EPA believes that no Government actions to limit the uncertainties in private sector response are appropriate at this time. However, if private capital flow was very slow and adverse

environmental effects were resulting from the investment rate, indirect financial assistance in forms such as loans, loan guarantees, or investment credits could be used to accelerate investment. If facility location or user charge problems arose, the Government could impose a franchise system with territorial limits and user charge rate controls. Long-term care of hazardous waste storage and disposal facilities could be assured by mandating use of Federal or State land for such facilities.

EPA studies indicate that treatment and disposal of hazardous wastes at central processing facilities are preferable to management at each point of generation, in most cases, because of economies of scale, decreased environmental risk, and increased opportunities for resource recovery. However, other forces may deter creation of the "regional processing facility" type of system. For example, the pending effluent limitation guidelines now being developed under authority of the Federal Water Pollution Control Act may force each generator to install water treatment facilities for both hazardous and nonhazardous aqueous waste streams. Consequently, the absolute volume of hazardous wastes requiring further treatment at central facilities may be reduced and the potential for economies of scale at such facilities may not be as strong as it is currently.

Given these uncertainties, several projections of future events can be made. Processing capacity required nationally was estimated assuming complete regulation, treatment, and disposal of *all* hazardous wastes at the earliest practicable time period. Estimates were based on a postulated scenario in which approximately 20 regional treatment and disposal facilities are constructed across the Nation. Of these, 5 would be very large facilities serving major industrial areas, each treating 1.3 million tons annually, and 15 would be medium-size facilities, each treating 160,000 tons annually. An estimated 8.5 million tons of hazardous wastes would be treated and disposed of away from the point of generation (off site); 1.5 million tons would be pretreated by generators on site, with 0.5 million tons of residues transported to off-site treatment and disposal facilities for further processing. Each regional processing facility was assumed to provide a complete range of treatment processes capable of handling all types of hazardous wastes; and, therefore, each would be much more costly than existing private facilities.

Capital requirements to create the system described are approximately $940 million. Average annual operating expenditures (including capital recovery and operating costs) of $620 million would be required to sustain the program. These costs are roughly estimated to be equivalent to 1 percent of the value of shipments from industries directly impacted. In addition, administrative expenses of about $20 million annually for Federal and State regulatory programs would be necessary. For the reasons stated earlier, however, capacity and capital requirements for a national hazardous waste management system may be smaller than indicated, and more in line with the capacity and capital availability of the existing hazardous waste management industry.

In summary, the conclusions of the study are that (1) a hazardous waste management problem exists and its magnitude is increasing; (2) the technical means to solve the problem exist for most hazardous waste but are costly in

comparison with present practices; (3) the legislative and economic incentives for using available technology are not sufficient to cause environmentally adequate treatment and disposal in most cases; (4) the most effective solution at least direct cost to the public is a program for the regulation of hazardous waste treatment and disposal; (5) a private hazardous waste management service industry exists and is capable of expanding under the stimulus of a regulatory program; (6) because of inherent uncertainties, private sector response cannot be definitely prescribed; (7) several alternatives for Government action are available, but, based on analyses to date, EPA is not convinced that such actions are needed.

EPA has proposed legislation to the Congress that is intended both to fulfill the purposes of Section 212 of the Solid Waste Disposal Act as amended and to carry out the recommendations of this report. The proposed Hazardous Waste Management Act of 1973 would authorize a regulatory program for treatment and disposal of EPA-designated hazardous wastes; the States would implement the program subject to Federal standards in most cases. All studies performed in response to Section 212 will be completed in time to serve as useful input to congressional consideration of our legislative proposal.

UNIVERSITY OF FLORIDA
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Containing the flow of sewage sludge

The technological and financial effort needed might turn out to be an investment with some return

"Two years ago, you could have held this conference in a telephone booth," Wesley Gilbertson, deputy secretary of Environment, Commonwealth of Pennsylvania, told a luncheon session of the National Conference on Municipal Sludge Management (NCMSM). That about 300 people attended the NCMSM attests to the sharp acceleration of interest in the sewage sludge problem. There might have been even more interest and progress in dealing with sludge problems, Gilbertson reminded his listeners, if about 50% of the environmental protection funding had not been impounded, and if applications for what funds there are were not bogged down in so much red tape.

The sludge volume can be expected to increase materially because of existing and forthcoming requirements for advanced waste water treatment. One need only look at the recent "sludge war" between the District of Columbia and neighboring Maryland counties to perceive that when it comes to sharing this volume of sewage sludge, a municipality is willing to be magnanimous. Nearby jurisdictions' adamancy in declining what is so generously offered seems to equal or exceed the municipality's generosity. This particular sludge war was settled in June; the sludge will be carefully disposed of at selected sites in Montgomery and Prince Georges Counties, Md.

Modifications to this scheme of things may be in the offing, however. These modifications, as well as new and existing approaches to the sludge problem, concerned the NCMSM, held at Pittsburgh, Pa., in June, and sponsored by Allegheny County, Pa., in association with the Pittsburgh Section of the American Society of Civil Engineers (ASCE), and the U.S. EPA.

The deep six

The City of Philadelphia (Pa.) conducts what its Water Department (PWD) calls a very simple "unit" operation. Sewage sludge is anaerobically digested and pumped to a lagoon for thickening to about 12.5% solids. The thickened sludge is then transferred to a barge of 2-million gal capacity, which is towed out to sea. Discharge of the sludge occurs over 6-mile course at about 30,000 gpm.

Prior to May 1973, the Philadelphia sludge disposal site was a 1 × 2-mile rectangular area 13 miles east of Cape Henlopen, Del. Water depth was 60 ft. The environmental soundness of this sewage sludge disposal method was brought into question by citizen and government groups in early 1970. Philadelphia therefore retained the Franklin Institute Research Laboratories and Jefferson Medical College, both of that city, to sample water and sediments at the disposal site and ascertain what, if any, harmful effects were noted.

A year-long joint study by these organizations revealed no lasting harmful effects, according to the PWD. While there was certain federal and regional group criticism of some of their report's mathematical statistics, the chemical, physical, biological, and environmental observations, as well as sampling methods, were sound, Steven Townsend, coordinator of sludge disposal activities for the PWD, said.

The Marine Protection, Research, and Sanctuaries Act of 1972 (P.L. 92-532) put a "crimp" in the PWD's ocean disposal program. For example, under a P.L. 92-532 permit, issued April 23, 1973, the PWD must take its sludge 50 miles off the coast at a 175% barging cost increase. Moreover, 40 parameters must be analyzed before the barge leaves the treatment plant. However, standards appear to be met, with the possible exception of mercury and cadmium in the "solid phase," for which procedures are still in draft form.

Typical pollutants found in primary sewage sludge

METALS	Ppm
Cadmium	Less than 100
Chromium	714
Copper	81–1000
Lead	Up to 404
Mercury	3.2–14.5
Nickel	24–400
Zinc	306–1950
PATHOGENS	**Per 100 ml**
Fecal coliform (raw)	11.4 million
Fecal coliform (digested)	390,000
Salmonella (raw)	460
Salmonella (digested)	29
PESTICIDES	**Ppm**
Aldrin	N.D.–16
Chlordane	N.D.–18.4
DDD	N.D.–0.5
DDT	N.D.–1.1
Dieldrin	0.08–2.0
PCB	N.D.–105

N.D. Not detectable.
Source: Conference papers.

The PWD regards P.L. 92-532 as being overly aggressive in ocean protection, while failing to consider hazards of sludge disposal alternatives. Nonetheless, even with cost increases under its permit accounted for, the PWD finds ocean disposal expenses to be about $17/dry ton of raw sludge, as compared to $50/dry ton (average) for nine other disposal alternatives, or $62/dry ton for incineration. The PWD also maintains that ocean disposal results in the equivalent of a land loading rate of 2 dry tons/acre/year; the EPA would allow a land loading rate of 54 dry tons/acre/year.

The big spread

With prospects of increasing restrictions on ocean disposal of sewage sludge, and inaccessibility of the ocean to many jurisdictions, land disposal methods or incineration must be examined more closely. Thus, the NCMSM heard about the latest pros and cons of land spreading, landfilling, and incineration. Joseph Farrell of EPA (Cincinnati, Ohio) told the NCMSM that he expects ocean and outfall sludge dumping to decrease sharply; therefore use of land disposal or other methods must increase.

A big problem with landfilling is that sites are becoming increasingly scarce. Also, where a site may be established, the land is often too expensive to acquire, or heavy citizen opposition is encountered. Moreover, requirements for "inerting" heavy metals, pathogens, viruses, and pesticides, to avoid groundwater pollution stemming from such a landfill, will become very stiff.

Probably, emphasis will finally be on the old-new technique of land use of sludge for agricultural needs, such as soil conditioners and fertilizer supplements. One example of such disposal takes care of 80,000 gpd near Pensacola, Fla.; the disposal method is being tested by Baseline, Inc., of that city, together with the Universities of Florida and West Florida, and the County of Escambia. The optimum rate of sludge application for growing corn, sorghum, and soy was found to be 1 in./week. Steers are to be fed these grains for six months, and their tissues then tested for heavy metals and other harmful sub-

stances. Water from 70-ft deep wells will also be tested.

Stephen Black, of the Ontario (Canada) Ministry of the Environment, told the conference of using sludge (3–5% solids) for fertilizer and soil amendment for growing corn. He estimated cost equivalent as that of nitrogen–phosphorus–potash fertilizer worth about $7.50 Canadian/1000 Imperial gal. The pH must exceed 6; metals, other chemical content, quality, and possible health effects must be closely monitored, and human and cattle consumption of the corn forbidden.

Elliot Epstein and John Walker, of the U.S. Department of Agriculture (USDA, Beltsville, Md.), are looking at composting and trenching of sludge, respectively. While these techniques have practical and institutional problems to be worked out, and require well-controlled conditions, they show promise. Composting, particularly, may help to attack sludge and garbage disposal problems simultaneously, in the near future. Epstein estimated costs for composting 200 tpd of sludge (20% solids), during a seven-day week, at $7.31/wet ton. This estimate does not include land acquisition, hauling, distribution, or cover in cold or wet places, nor does it account for any offsetting benefits. The $7.31/wet ton is equivalent to $30/dry ton.

Turning on the heat

USDA's Epstein estimates that primary sludge provides only 1% of nitrogen directly usable for agriculture. That, plus the fact that fuel used to be cheap, was a motivating factor for sludge incineration. Incineration, though fraught with furnace, air pollution, and residue disposal problems that had to be tackled, was the route that the Allegheny County Sanitary Authority (Alcosan) took. To Alcosan, potential usefulness to the sludge appeared marginal, and coal, and after 1970, natural gas, were cheap and plentiful.

In 1973, Alcosan introduced vacuum filters to dewater sludge. The dewatering polymer then cost $2.63/dry ton; the dewatering cost was $19.92/dry ton (to 22% solids, on the average). Incinerator costs in 1973 averaged $40.35/dry ton. These costs have gone up markedly with the petroleum and petrochemical crunch; moreover, uninterrupted gas supplies are not assured.

Alcosan's first approach will be to utilize, to the maximum possible extent, heat presently wasted. For the future, Alcosan looks to burning a mixture of sewage solids and solid waste materials with a view to generating steam as a final product. George Brinsko, Alcosan's plant superintendent, reminded the NCMSM that steam is a product which is presently in great demand.

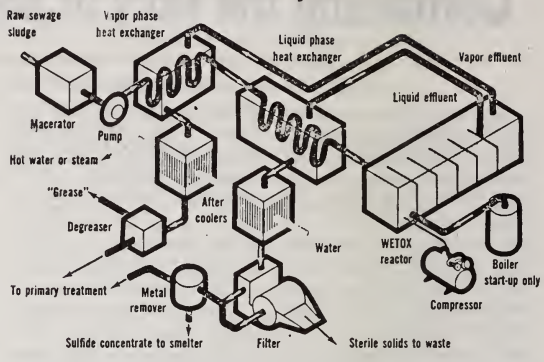
Another "hot" approach to sludge handling is pasteurization at 59–73°C for at least one-half hour, Gerald Stern of EPA/Cincinnati told the conference. Stern said that while properly digested sludge should not be harmful, nothing should be left to chance, since sewage sludge can teem with viruses, bacteria, protozoa, and parasites. He estimated that it would take 4.6 million Btu/ton to pasteurize 1 ton of sludge of 5% solids, but he expressed the thought that sufficient methane can be derived from volatile material destroyed to give 6.9 million Btu/ton.

Asset values

The Resource Recovery Division, Barber-Colman Co. (Irvine, Calif.), has devised the PURETEC wet oxidation (WETOX) system which operates at 600 psi and 450–465°F. Vice-president and division manager W. Martin Fassell explained that this system, under mildly acid (pH 3) conditions, will destroy 75–85% of chemical oxygen demand. He estimated sludges to have 7500–10,000 Btu/lb worth of volatile solids, so that substantial energy generation is possible. Moreover, about 35–50 lb of aliphatic "grease" or 1 bbl of "oil" per dry ton of sludge treated is obtainable for use as fuel or as petrochemical feedstock.

Fassell said that heavy metals become recoverable, since his company's system destroys most organics, or reduces them to low molecular weight. Resulting sand or ash can be stripped of metal values by standard hydrometallurgical techniques. This is food for thought, since in Orange County, Calif., alone, $1 million worth of metals are normally dumped into sewers.

Barber-Colman PURETEC WETOX system



Organic nitrogen in sludge is totally converted to ammonia which can easily be lime-stripped. About 99% of the ammonia is recoverable, and has a minimum of $3.65/ton of sludge treated. Fassell suggests processing it to ammonium sulfate or phosphate for a highly concentrated fertilizer. Fassell also believes that denitrification of sludge by the PURETEC method might result in an operating credit for a treatment plant.

Acetic and propionic acids are also obtainable; indeed, 250 lb of acetate/dry ton of sludge processed, are produced. Fassell assigns the acetic acid by-product a value of $21.60/dry ton of sludge treated, based on a current methanol price of $0.086/lb. Pilot studies of the PURETEC–WETOX system are being conducted in Orange County, Calif., and in Philadelphia, Pa.

Attacking the problem

The sludge problem is thus being attacked with a multiplicity of approaches. These approaches involve methods of sea and land disposal, incineration, and pasteurization, with more recent trials of energy and resource recovery. Also to be tackled is the problem of dealing with a citizenry that becomes highly emotional whenever the matter of sludge disposal is brought up.

Donald Berman, Allegheny County's director of public works, expressed general optimism in his keynote address when he stated what he called Berman's Rule: Sludge management problems are solved deliberately and slowly, but inexorably. If the various fund-cutting groups can forbear from springing new surprises all the time, and if the public's emotions can be calmed through a well-conceived program of citizen education and involvement, Berman's Rule will indeed hold true. JJ